Design of Cueing in Multimedia Practicals

Design of Cueing in Multimedia Practicals:

Studies into Cueing Formats, Learner Control and Collaboration

to Support the Learning of Complex Skills

“We can be more whole, or less whole; more fragmented, or less fragmented; more alienated, or less alienated – and an integral vision invites us to be a little more whole a little less fragmented, in our work, our lives, our destiny.” (p. xii)

“… many arguments are not really a matter of the better *objective* evidence, but of the *subjective* level of those arguing. No amount of scientific evidence will convince mythic believers; no amount of bonding will impress aggressiveness; no amount of holism will dislodge pluralism – unless the individual is ready to develop forward through the dynamic spiral of consciousness unfolding.“ (p. 14)

Wilber, K. (2000). *A theory of everything: An integral vision of business, politics, science, and spirituality*. Boston: Shambhala.

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CHAPTER 1 – **General introduction**

Professional work environments are changing ever more rapidly, requiring companies to be flexible and adaptive. Employees working in these companies are expected to demonstrate life-long learning competences, such as the ability to independently solve a variety of occurring problems in professional practice. The importance of competences is increasing because companies no longer settle for graduates that just know and do a lot in general; they are also supposed to be able to actually apply their general knowledge and skills in specific professional situations.

The demand for flexible and adaptive employees has triggered educational change. Teacher-centred instruction, going from teacher to students and placing the learning of isolated facts and skills in the central position, is no longer considered sufficient. What is also considered necessary is more student-centred instruction, promoting students to actively and independently collect information themselves and placing the training of competences in the central position. The training of flexible problem-solving behavior is aimed at transfer of what is learned in education to work settings. Such complex skills require many hours of training, and novice learners need support to acquire them. Computer programs aimed at the acquisition of problem-solving competences for a variety of domains can be referred to as competence-based multimedia practicals. The general research question of this thesis is: *How should support for the acquisition of problem-solving skills in competence-based multimedia practicals be designed?*

This general introduction first describes problem-solving tasks and support. The theoretical framework underlying this thesis explains why support is expected to facilitate schema-based learning in order to enable transfer. The second section introduces the main processes of schema-based learning, adequate formats of task-valid cognitive support (referred to as cueing) to facilitate these processes, and the practical we adapted for our research. The third and last section presents concrete research questions on designing support (i.e. cueing) in multimedia practicals, together with an overview of the content of this thesis.

Problem solving 'whole tasks', process support and transfer

The challenge for educational designers is to come up with process support, which facilitates the process of effective acquisition of problem-solving skills for a certain domain. The problem-solving process can be characterized as a complex interaction of factual knowledge, meta cognitive strategies, experiences, beliefs, and social factors. Expert problem solvers manage this complex and dynamic process through the application of problem-solving strategies, i.e. procedures that direct and monitor the problem-solving task (Alexander & Judy, 1988).

Effective training for problem-solving skills in a certain domain means that adequate tasks and formats of support have to be provided. With the paradigm shift from more objectivistic towards more constructivistic approaches to instructional design, researchers (see e.g., Brown, Collins, & Duguid, 1989; Jonassen, 1991) have started to emphasize the importance of authentic 'whole tasks' training programs of longer duration based on real-life problems and situations. 'Whole tasks' train learners all constituent skills at once, but conditions become more complex during training (Van Merriënboer, 1997). Lave (1988) criticized research that failed to show transfer by pointing out that in laboratory studies of transfer "the target analogy is a pre-formulated, static object, and its unmodified use by the subject is the object of exercise" (p. 37). Lave argued that learning is always situated, and rightly questioned the premise that knowledge and skills are 'prêt a porter'. Transfer can be defined as the ability to apply previously learned strategies in new situations.

The contemporary view of instructional designers (e.g., Van Merriënboer & Sweller, in press) is that real-life tasks in training programs of longer duration should be the driving force for complex learning. This means that theorists and researchers would need to broaden their scope. For computer-based instruction, researchers should not only have attention for short tasks and tidy domains, like mathematics and programming, but also for larger tasks and ill-structured domains, like psychology and law, where there are many ways to look at issues, multiple viewpoints, several answers to a problem. Time frames larger than those typically associated with laboratory training studies need to be considered. Furthermore, theorists must embrace more abstract, structural accounts of similarity across a variety of problem situations over longer periods of time, and need to pay more attention to the influence of prior knowledge and experience (Carraher & Schliemann, 2002). Learning to solve problems entails the building up of structures, schemata and intuitions that are developed over longer periods of time (like preparing documents and pleas for a number of law case files during a court practical of about three months).

Where traditional institutions for higher education may use field trips, internships, or laboratories to provide authentic 'whole task' problem-solving experiences, distance education is forced to look for alternative methods like competence-based multimedia practicals. Instructional designers at the Open University of the Netherlands have gained considerable experience with such methods and process support for 'whole tasks' like: identifying environmentally protected areas (soil science; Ivens et al., 1998); modeling stress-factors that cause mental overload in workers (labor psychology; Gerrichhauzen et al., 1998); and selecting a suitable employee (personnel assessment; VanderMeeren et al., 1997). However, systematic research on the effects of such methods and support has remained scarce in the last decades.

Authentic 'whole tasks' in multimedia practicals typically have a study load of one or more dozens of hours, and have to be split up in steps to make them 'digestible' for novice learners. Next and furthermore, the amount and formats of support for every step need to be determined and optimized. Nadolski, Kirschner and Van Merriënboer (in press) recently examined the optimal number of steps that is needed to support a 'whole task', focusing on step size, task complexity and task-segmentation. This thesis will focus on *process support within these steps*.

Schema-based learning and cueing

The purpose of process support in training is to help learners employ correct, previously learned strategies in new situations. Over many ages, feedback is regarded as an essential element to support training. Plato and Aristotle recognized the need to stimulate and motivate students; in the 12th century figs, nuts and honey were used to reward students; in the 20th century, extensive research was devoted to study feedback in programmed learning situations. The relatively recent acceptance of more constructivistic learning paradigms and the use of the computer as a medium for instruction have caused instructional designers to radically re-examine the concept of feedback (for a review, see Mory, 1996). Especially for authentic problem-solving in complex task domains, for which the learner does not need to find one right answer but a possible solution among many, the mastery of effective strategies appears to be the key to more expert-like problem solving. Problem solvers must learn to select and combine multiple rules to reach an optimal solution. From this broadened perspective on feedback, researchers have recognized the need to investigate effective formats of feedback that are specifically designed to support the cognitive processes underlying successful task performance. These formats are not limited to outcome-oriented feedback alone, and include process-oriented types of feedforward and feedthrough. This so called task-valid cognitive feedback is referred to as cueing in this thesis; cueing aids learners while they construct solutions to authentic problems (Balzer, Doherty, & O'Connor, 1989). Cueing facilitates the acquisition of effective problem-solving schemata, which learners need as they construct solutions to authentic problems. From expert-novice research (e.g., Anderson, 1987) it has become clear that when learners lack adequate cognitive schemata, they are compelled to use weak problem-solving methods.

Schema automation and schema construction

We define a *schema* as a cognitive structure that enables learners to recognize and classify occurring problems, thus providing analogies to reach solutions for unfamiliar aspects of the problem. Both the processes of schema automation (to master the recurrent constituent skills) and schema construction (to master the non-recurrent constituent skills) are responsible for transfer of problem-solving skills. *Schema automation* through a compilation of specific, weak-method problem solutions alone is effortful and time-consuming, and inhibits the processing of more general aspects of the task structure that is required for schema construction. The resulting transfer will be *near* and limited to problems that are highly similar to the ones used during training. The *construction* of relevant schemata that offer useful analogies is important to reach *far* transfer.

Transfer from one task to another, not similar task is achieved by arranging learning situations so that a learner can gain insight into the problem to be solved. This idea stems from the Gestalt theory of 'structural understanding'. Bartlett (1932) first made notice of this idea in his schema theory. Salomon and Perkins (1987) describe the far transfer mechanism as the result of 'mindful abstraction' from one situation and application to another, and refer to it as 'high road transfer'. By combining elements consisting of 'lower-level schemata' into 'higher-level schemata', it is that expertise develops. Noticing the analogy is a prerequisite for successful transfer in realistic problem situations. When analogies are not noticed spontaneously, the instructional question becomes: How can analogies be made more noticeable or salient to the learner, so that analogies can be applied by the learner when generating solutions for new transfer problems? In constructing schemata it may help to explicitly state that a schema is applicable in certain transfer situations, or by using cues to activate the appropriate schema.

Cueing: task-valid cognitive feedback

In ordinary language, cueing appears to be a rather versatile and confusing term that is related to various topics, like playing pool (ball cueing), sign language (cued speech), disk jockeys scratching (or cueing) records, and standing in line. In the educational context of providing clues or cues to learners, the term c*ueing* is defined in this thesis as an instructional technique to facilitate the interpretation and construction of problem schema to enable *transfer* in solving similar (near transfer) and related problems (far transfer).

Generally, conventional training tasks provide little cueing to the learner to facilitate mindful abstraction, which results in sub-optimal automation and construction of schemata (e.g., Quilici & Mayer, 1996). In this thesis, the process of schema-based learning has guided the design of cueing. Cueing should offer a combination of both specific, descriptive examples of solutions during practice (to facilitate schema automation), and more general, prescriptive worksheets that demand the mindful abstraction from these concrete examples (to facilitate schema construction). Our research therefore focuses on two formats of task-valid cognitive feedback (referred to as *cueing*) to support both schema automation and construction: more specific worked-out examples, a product-oriented format that provides salient characteristics of solutions, and more general process worksheets, a process-oriented format that demands the mindful abstraction from these examples.

Research questions and content overview

Feedback research areas include information content, learning outcome and task, timing, and various motivational functions that feedback might provide. This research re-examines feedback, that in the last decades has been primarily studied in contrived experimental learning situations, in the form of outcome-oriented feedback, provided after a learner responds to relatively simple and self-contained tasks. It re-examines the effects for task-valid cognitive feedback (information content), on the performance of authentic training and transfer tasks (learning outcome and task), in a multimedia practical from the domain of Law, and takes learner control, timing and motivation into account. The multimedia practical *Preparing a plea*, that we adapted for our research purposes, and the main research questions, that will be addressed in the following chapters of the thesis, are introduced in the next section.

Preparing a plea

For this research, *Preparing a plea*, a multimedia practical that teaches students to prepare a plea in court (Wöretshofer et al., 2000), was adapted. In this program the learner enters a simulated task environment, modeled after a realistic situation, in the role of trainee in a virtual law firm. After studying some 'theory' on how to plea a case in court, and getting acquainted with various support tools in the program, the trainee must prepare pleas for various cases using this theory. The case files are available within an (virtual) office. The trainee receives several task assignments for each step to guide the study and receives feedback from a (virtual) senior (virtual) employee (the coach) of the firm. A short description of the program goes with Figure 2.1 in Chapter 2.

For this general introduction it now suffices to know that every 'whole task' of preparing a plea is segmented into 9 steps, and that for most steps cueing is provided (by the coach) in the form of worked-out examples and process worksheets. The *worked-out examples* are a type of feedback provided upon completion of each step (e.g., drawing up a pleading note), offering a specific expert solution (i.e. the pleading note as drawn up by the coach). The *process worksheets* are a type of feedforward provided upon assignment of the step in the form of driving questions that have to be answered to carry out the step (e.g., checkpoints for drawing up a pleading note). These driving questions direct the learners' attention to conditions under which skills are actually practiced, instead of just researching presentation of information as in most current research (Mason & Bruning, 1999; Morrison et al., 1995).

Research questions and hypotheses

Our experimental studies focus on effective orientation and timing of cueing (i.e. worked-out examples and process worksheets) to support training and transfer. The following research questions are addressed in this thesis.

First of all, we have raised some general research questions: Is it possible to provide *guidelines* on what constitutes adequate cueing? Is it possible to describe how adequate cueing formats relate to schema-based learning and transfer? Is it *feasible* to study examples and worksheets in authentic 'whole tasks'? Do students *appreciate* these formats of cueing? **Chapter 2** contains a theoretical model for schema construction with guidelines for cueing, which was derived from extensive literature research. Some preliminary results from a pilot study on students' appreciation of these cueing formats are presented.

A second group of questions pertains to the *orientation* (either product- or process-oriented) of the two cueing formats and its relation with task-type, training and transfer performance, as predicted by the theoretical model. Do learners with cueing actually outperform those without cueing? Do worked-out examples enhance near transfer by stimulating imitation processes for similar tasks? Do process worksheets foster far transfer by stimulating mindful abstraction processes to transfer tasks? Can we notice differential effects for both cueing formats on performance for more process-oriented and more product-oriented tasks? Based on the model for schema construction, we hypothesized that the combination of both cueing formats would be most effective, with worked-out examples enhancing near transfer and process worksheets enhancing far transfer. **Chapter 3** describes a first experiment that compared the effects of cueing formats on performance on both a process- and product-oriented task and a training plea, and on the performance on two transfer pleas that had to be given after two weeks and two months, respectively.

A third group of research questions deals with the effects of learner-controlled *timing* of cueing. When students can adapt training to their needs, they are supposed to learn the deeper, structural elements more effectively (Milheim & Martin, 1991). Do students with learner-controlled cueing outperform those with system-controlled cueing on a training- and transfer task? What is the right moment for learners to demand process worksheets? We hypothesized that students with learner-controlled cueing outperform those with system-controlled cueing on both the training and transfer tasks, and that the right moment for offering a process worksheet depends on the individual student. **Chapter 4** addresses these questions and describes a second experiment that compared the effects of a learner-controlled and a system-controlled cueing condition with a no cueing condition on a training and transfer task. This study also offers some preliminary insight into what might be the 'teachable moment' to offer process worksheets.

Fourth, with environments increasingly being designed and oriented towards *collaborative work* in groups of real or simulated peers, learner control and cueing can also be examined in learners' social context (Kay, 2001). Could it be a feasible and teacher-extensive option to complement individual cueing within a multimedia practical with small group collaboration on intermediate learning outcomes to support learning? What are the effects of cueing and small group discussions on process- and product-oriented training tasks and transfer pleas? What are the effects of cueing and task-type on the level and type of cognitive activity during these small group discussions? We hypothesized that both cueing and collaboration would increase performance on the training and transfer tasks, and that the level of cognitive activity during group discussion would be highest for those receiving cueing. **Chapter 5** describes the results of a third experiment studying the effects of cueing and task type on learning outcomes and group discussions, by comparing a 'cueing/collaboration', a 'no cueing/collaboration', and a 'no cueing/no collaboration' condition. Students had to send in individual reports that were discussed and adapted during collaborative group work. Discussions were videotaped and analyzed to get an impression of the cognitive activities.

Finally, the general discussion in **Chapter 6** recaptures the theoretical guidelines and model, and reviews the results from the pilot study and three experiments. It presents practical implications for the design of cueing in multimedia practicals, and suggests lines of future research.

CHAPTER 2 – **Cueing for schema construction***

Abstract

In competence-based learning environments, schemata play an important role in solving complex and authentic problems. Adequate *task-valid cueing* is considered to facilitate both recall and interpretation of available schemata (task performance) and the construction of new schemata (learning). This chapter provides guidelines for cueing, which aim at the improvement of (1) task performance in complex learning environments, (2) schema construction, and (3) monitoring. A model presents the relationships between cueing on the one hand and schema interpretation, schema construction, and monitoring on the other hand. The guidelines are used to evaluate *worked-out examples* and *process worksheets*, two formats of task-valid cueing that appear useful in competence-based learning environments. Worked-out examples support the inductive processing of concrete descriptions to construct schemata, while process worksheets support the deduction of concrete problem solving steps from general prescriptions. Illustrations are provided from the domain of Law.

Cueing for schema construction: Designing problem-solving multimedia practicals

Graduates from higher education should be able to apply acquired knowledge and skills in their professional domain. They should demonstrate sufficient problem-solving ability to handle complex tasks in a variety of authentic situations (Brown, Collins, & Duguid, 1989; Jonassen, 1991). The ultimate goal of higher education is the achievement of competence, and the associated form of learning is called *competence-based learning*. We define competence as the whole of knowledge and skills which people have at their disposal and which they can efficiently and effectively use to reach certain goals in professional situations (Kirschner, Van Vilsteren, Hummel, & Wigman, 1997).

Solving complex problem-tasks may be seen as a form of competence-based learning, where available schemata have to be recalled and interpreted, and more efficient schemata have to be constructed. *Schemata* are cognitive structures that relate task characteristics to each other and to approaches to solve problems (Gagné, Yekovich, & Yekovich, 1993). Adequate cueing provides learners with information about the task, which facilitates both interpretation and construction of schemata.

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* Based on: Hummel, H. G. K., & Nadolski, R. J. (2002). Cueing for Schema Construction: Designing Problem-solving Multimedia Practicals. *Contemporary Educational Psychology, 27*(2), 229-249.

Instructional guidelines on adequate cueing appear to be scarce. Effects of cueing have primarily been studied in contrived experimental learning situations in the form of outcome feedback, provided after a learner responds to relatively simple and self-contained tasks (e.g., Mory, 1996). Results from these studies cannot be used for competence-based learning environments, which are based upon more complex and inter-related tasks with diverging solutions. We should therefore re-examine cueing within a paradigm where learners must actively interpret and construct schemata while solving these complex and authentic tasks. In other words, it should provide support for learners who create their own meaning and internal reality, and not simply accept someone else's single reality.

Cueing supports both performance and learning when it takes the form of *task-valid* cognitive feedback (e.g., Balzer, Doherty, & O'Connor, 1989). Cueing thus contains information about task-characteristics and the state of task-execution. Recent research (e.g., Narciss, 1999; Whitehall & McDonald, 1993) shows a positive effect of task-valid cueing on the interpretation of available schemata; a larger amount of task-valid information in cueing leads to better *performance* on the complex task. Balzer, Doherty and O'Connor (1989) show that task-valid cueing improves *learning* to continuously monitor the adequacy of available schemata, and the necessity to construct more efficient schemata. We provide guidelines to determine what constitutes adequate cueing, and describe how cueing relates to schema interpretation, schema construction and monitoring in a model. To achieve this, the structure of this chapter will be as follows.

Section 2 describes the kind of tasks and possible formats of cueing in multimedia practicals. As an example of such an environment we use *Preparing a plea* (from the domain of Law), where students are taught to prepare the plea of a case in court. Four formats of cueing are distinguished, depending on the orientation (either process- or product-oriented) and the information (either abstract or concrete) they contain: worked-out examples, modeling examples, templates, and process worksheets.

Section 3 describes how cueing facilitates the interpretation of available schemata in complex task performance when it (a) reflects the complexity of the task, (b) serves as an embedded support device, and (c) makes learners persevere in attaining the goal competence.

Sometimes available schemata appear insufficient to solve a problem and new, more efficient schemata need to be constructed. Section 4 describes how cueing facilitates schema construction when it (a) reflects the relations between task characteristics, (b) saliently presents these task characteristics, (c) facilitates transfer, (d) optimizes available working memory, and (e) is presented just in time. We explain why a combination of process worksheets (process / abstract) and worked-out examples (product / concrete) appears most suitable to facilitate schema construction.

Table 2.1: Relations between a number of conditions in complex and authentic problem-solving tasks and guidelines for effective cueing

	(if …) **Conditions in complex tasks**	(… then) **Guidelines for adequate cueing**
COMPLEX LEARNING		
1	The task is complex	Cueing should reflect task complexity
2	There is a need for performance support in the complex learning environment	Cueing should serve as an embedded support device in the learning environment
3	Learner's inclination to comply with the task assignment needs to be increased	Cueing should a. not be disparate from the targeted competence, and b. induce perseverence in attaining this
SCHEMA CONSTRUCTION		
4	Complex relations exist between tasks and steps	Cueing should reflect the relations between and within tasks
5	Relations between task characteristics can be made clear	Cueing should be task-ordered and saliently describe relevant task characteristics
6	Task characteristics can be related to approaches that are applicable to a variety of tasks	Cueing should both support practice and facilitate transfer
7	Mental effort needs to remain within threshold working load capacity	Cueing should redirect attention from extraneous to germane processes in optimizing available working memory
8	Task characteristics determine when schemata need to be constructed or used	Cueing should be presented just-in-time, depending on the task characteristics
MONITORING		
9	Self-oriented and goal-oriented complex learning needs evaluative questioning	Cueing should induce or provide evaluative questioning of the learning progress
10	Information on how to proceed in task-execution is needed	Cueing should provide elaborated (task-valid) information on how to proceed (e.g., about completeness / correctness)
11	Progress in the execution of complex tasks needs assessment	Cueing should contain task-valid information about attaining (intermediate) stages in the task execution

A learner continuously monitors whether cues can be understood by interpreting available schemata or new schemata need to be constructed. Section 5 describes how cueing facilitates monitoring when it (a) stimulates evaluative questioning during problem solving, (b) provides information about the progress, and (c) provides information about intermediate results. The relations between cueing, schemata, monitoring, and learning outcomes are brought together in a model for schema construction.

Finally, the discussion contains a preliminary assessment of the suitability of process worksheets and worked-out examples for competence-based learning. Indicative findings with *Preparing a plea* are related to future research on timing and orientation of cueing in multimedia practicals. We now end the introduction with the list of guidelines (see Table 2.1), each of which will be explained in the upcoming sections.

Tasks and cueing in complex learning environments

Complex and authentic tasks can be performed in multimedia practicals. They provide realistic situations in which meaningful learning through contextualized practice takes place (e.g., Brown, Collins, & Duguid, 1989). According to the four-component instructional design model for training complex skills (4C/ID model; Van Merriënboer, 1997), in complex learning both recurrent (procedural) constituent skills and non-recurrent constituent skills, for which the desired behavior is highly contextually dependent, have to be acquired and combined. Mastering *non-recurrent constituent skills* especially requires schema construction, since the application varies from problem situation to problem situation. Mastering *recurrent constituent skills* especially requires schema automation, since the application is the same for different problem situations. Attaining an integrated set of these constituent skills is referred to as the '*goal competence'* for which transfer should occur from problem situation to problem situation.

Kind of tasks in multimedia practicals

Tasks within multimedia practicals typically have a well-defined begin state, many possible pathways, not a well-defined end state, but well-defined constraints. Such tasks can be extremely large, but usually have a study load of about 30-50 hours. The task itself can be practiced as a whole, provided that the necessary support is given to the learners. Exemplary tasks are: identifying environmentally protected areas (soil science) (Ivens et al., 1998); modeling stress-factors that cause mental overload in workers (labor psychology) (Gerrichhauzen et al., 1998); and selecting a suitable employee (personnel assessment) (VanderMeeren et al., 1997).

We will draw examples from the multimedia practical *Preparing a plea*, that teaches students to prepare a plea in court (Wöretshofer et al., 2000). The systematic approach to the problem (SAP) of "pleading a case X in court" consists of nine steps in which constituent skills are practiced and combined: (1) ordering the file of case X;

(2) getting acquainted with the file; (3) studying the file; (4) analyzing the pleading situation; (5) determining the strategy for pleading note and plea; (6) writing a pleading note; (7) transforming the pleading note into a plea; (8) practicing the plea; and (9) actually carrying out the plea. The first seven steps are practiced and controlled individually by means of the multimedia practical; the last two are practiced and controlled by means of role-play. Figure 2.1 presents some of the screens a learner may encounter in *Preparing a plea*.

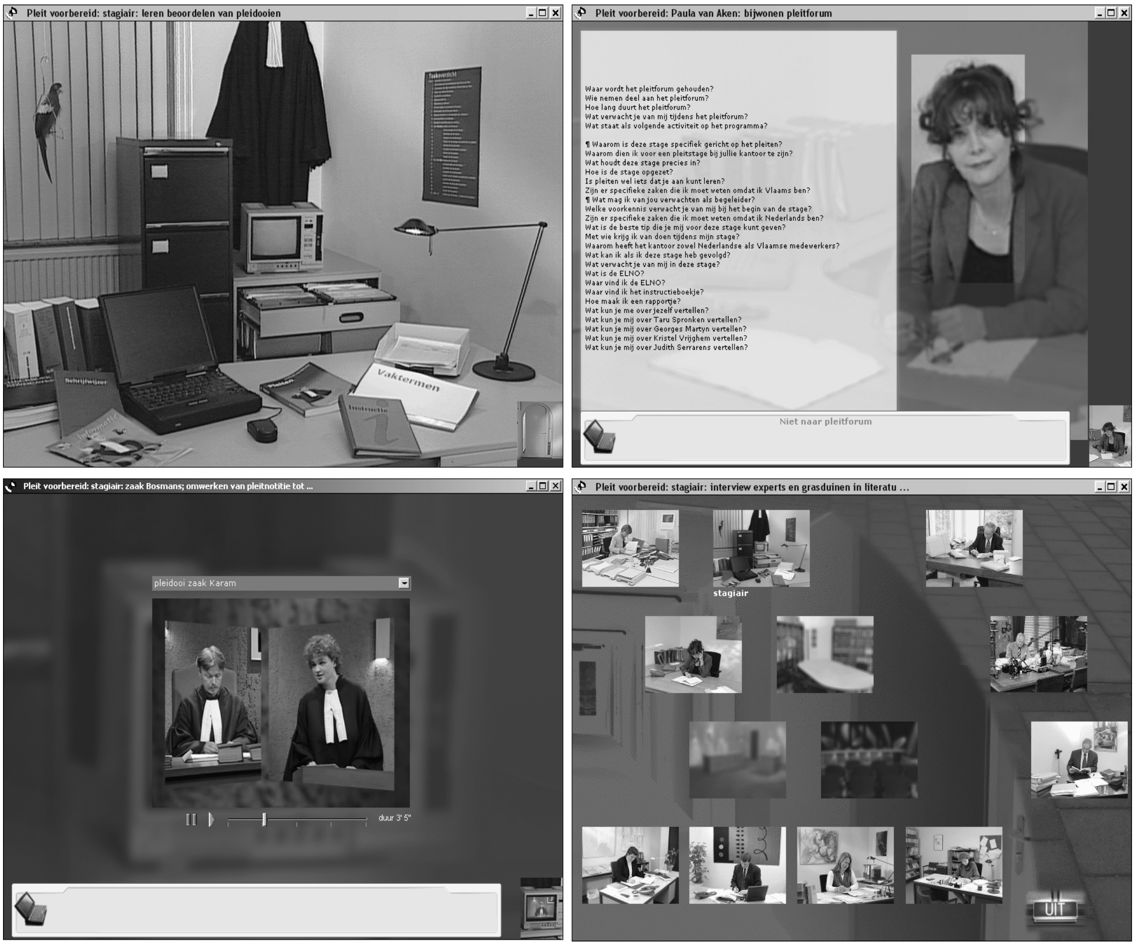

Figure 2.1: Screendumps from Preparing a plea: an example of a multimedia practical in the domain of Law The learner is given the role of trainee or junior lawyer in a (virtual) legal firm. He or she must prepare a plea for various cases. A (virtual) coach introduces the way a plea should be prepared and comments on various activities of the learner during preparation. Clockwise you find the following virtual environments: The trainee's office (where he/she can search a file cabinet or mailbox, make and and e-mail reports on tasks to the mentor); the mentor's office (where the trainee may go to ask questions); external experts and colleagues within the law firm that learner can consult; and a video player on which the trainee can observe -both good and bad- examples of pleas by others with the help of a 'plea checker'.

Formats of cueing in multimedia practicals

The term 'cueing' was introduced in Brunswik's (1956) lens model. In that model, both characteristics of tasks and of learners' progress on tasks are described in terms of a set of features or a profile of *cues*, used to predict final performance. According to Wood (1986) the execution of complex tasks involves a multiplicity of cues, a high degree of coordination among cues, and changing relations between cues. Cues provide information about the attributes of multiattribute objects of judgements in complex tasks. Schemata can represent the relations within and between these multiattribute objects.

More specifically, *task-valid cueing* contains information about task characteristics and their relations. On the one hand, it can be either process-oriented (e.g., a heuristic or a SAP) or product-oriented (e.g., a semantical network or a contents table). On the other hand, it can give either abstract or concrete information about the task. These aspects can be operationalized by four different formats of cueing (see upper box in Figure 2.2): (1) concrete, product-oriented cues, like worked-out examples (in *Preparing a plea* this could be a completely worked out pleading note); (2) concrete, process-oriented cues, like modeling examples (in *Preparing a plea* this could be a demonstration of how to hold a plea in court); (3) abstract, product-oriented cues, like templates (in *Preparing a plea* this could be a standard contents table of a pleading note); and (4) abstract, process-oriented cues, like process worksheets (in *Preparing a plea* this could be a list of questions to be answered to write a pleading note).

Process worksheets reflect the commonalities in a set of modeling examples. Worked-out examples and modeling examples are more concrete formats of cueing, offering a lot of context of the specific task at hand, but making it more difficult to discover standard structures or approaches that can be more generally applied. Templates and process worksheets are more abstract formats of cueing that are generally applicable in a variety of tasks. Templates reflect the commonalities in a set of worked-out examples (e.g., each pleading note should consist of an introduction, a body of content, and a final conclusion).

Process worksheets (abstract, process-oriented) and worked-out examples (concrete, product-oriented) are expected to differ in their effects on schema construction and learning outcomes; both are found in multimedia practicals, and can be considered useful from the perspective of the 4C/ID model (Van Merriënboer, 1997) and in relation to cognitive load theory (Sweller, 1988). Besides this, 'traditional' education has concentrated on the second format, while 'new' education now focuses on the first format. Of both formats we now present an example. (We included screendumps of examples of a process worksheet and a worked-out example in appendix 1, on pages 103-104.)

In *Preparing a plea* many task characteristics have to be considered in each step of the SAP, some of which are interrelated. For each step learners are offered a *process worksheet* (from now on PW) with driving questions. For instance, when analyzing a pleading situation (step 3) in order to draw up a pleading inventory, some of these questions are:

".....
4a. What are the most important arguments of the opposing party?
4b. Could you refute these arguments? If so, how?
5. Which articles of the law are of importance for this case?
6. Which criteria should be fulfilled?
7. What are the judicial consequences if these criteria are / are not fulfilled?
8. Which judicial consequence suits your client the most / the least?
…. et cetera"

At the end of each step learners can compare their reports with *worked-out examples* (from now on WOE) of the mentor to find out how an expert would deal with the questions in the PW. For instance, (a part of) the pleading inventory (step 3) might look like this (article numbers referring to Dutch Law):

"....
5. Which articles of the law are of importance for this case?
Art. 6:265 BW: in case of dissolution of agreements
Art. 6:271 BW: relating to over rulings (of disqualifications)
Art. 6:98 BW: relating to the amount of the compensation
Art. 6:74 BW: relating to the compensation
Art. 6:75 and 6:78 BW: relating to circumstantial evidence and accountability
6. Which criteria should be fulfilled?
Relating to shortcomings in the compliance:
- the demand is claimable (6:38-6:40 BW)
- Compliance stays out or is carried out in an inferior way. To establish this the content of the obligation concerned needs to be examined accurately (art. 3:33, 3:35, 6:2, 6:248 BW)
- compliance is justified by an appeal on the authority to suspend
Relating to dissolution (6:265 BW)
- there has to be a mutual agreement
- there has to be a shortcoming in the compliance
... et cetera"

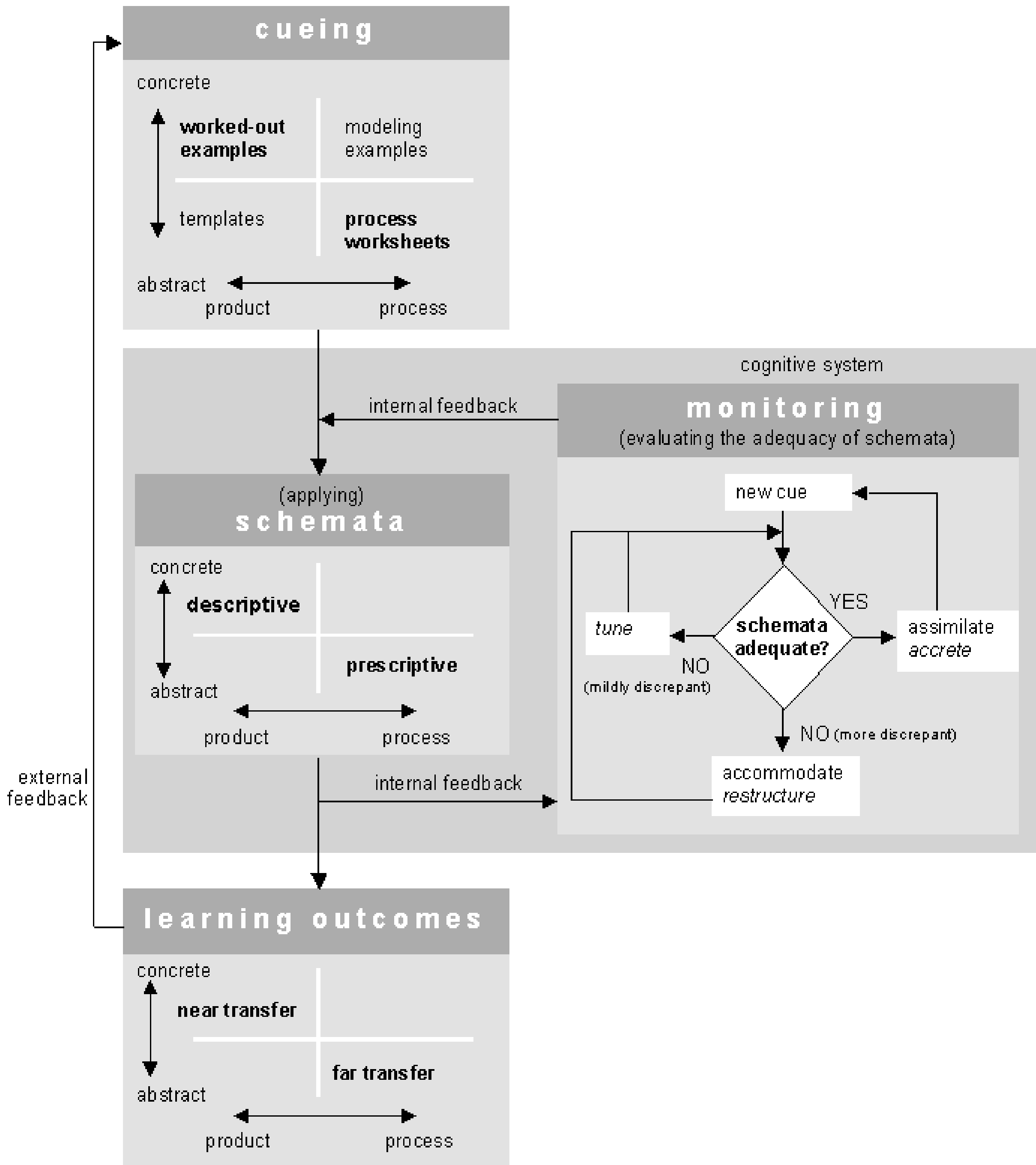

Figure 2.2: Model for schema construction

Cueing and schema-interpretation

Problem solving in a complex domain has been characterized as first recalling appropriate schemata available in long-term-memory, and then interpreting these schemata with the specific parameters of the problem at hand (Chi, Feltovich, & Glaser, 1981). Recalled schemata determine how the problem is solved because they determine what conceptual knowledge is used to elaborate the problem statement, and what approaches are used to solve the problem (Gagné, Yekovich, & Yekovich, 1993). Schemata have a dual function in complex learning: (a) they support the storing and retrieval of information in and from long-term memory, and (b) reduce the burden on working memory (by allowing multiple elements of information to be treated as a single element or chunk). Adequate cueing provides learners with opportunities to examine the adequacy of schemata, based upon information about the task characteristics and the state of task execution. We will now give guidelines for cueing that facilitates the recall and interpretation of schemata held in long-term memory by (a) reflecting the complexity of the task, (b) serving as an embedded support device, and (c) increasing the inclination to comply with task assignments.

Cueing should reflect task complexity (1). What makes a learning task a complex one? This guideline focuses on the *component* complexity of the task, operationalized by the number and form of information cues and judgements *within* the steps a learner takes during task performing (Wood, 1986). Learners should realize that authentic learning tasks require more judgements based on multiple cues. For instance, an experienced lawyer drawing up a draft version of a plea to be held in court, weighs a variety of both communicative and legal criteria which are often contradictory.

Cueing should serve as an embedded support device (2). Novice learners are unfamiliar with the complex problems presented in multimedia practicals and do not yet know how to approach them. The problem tasks representing the goal competence can be practiced as a whole, provided that necessary support is embedded in the learning environment. This article focuses on adequate task-valid cueing *within* the specific (nine) steps, identified in the SAP we described before. Cueing should serve as an embedded support device (Martens, 1998) in the learning environment, and give direction to the problem-solving process. Here, the term 'performance constraint' is probably more appropriate than the term performance support. We could compare this kind of support with training wheels on children's bikes, which prevent them from falling over (Carroll & Carithers, 1984). Cueing should be an important training wheel in multimedia practicals, while others are task decomposition and sequencing. (Nadolski, Kirschner, van Merriënboer and Hummel (2001) present an ID model that offers guidelines for optimizing the size and sequence of steps in multimedia practicals.)

Cueing should increase the inclination to comply with the task assignment (3). In complex learning environments it is important that task-valid information is processed successfully, and that learners are motivated to persevere in attaining the 'goal competence'. Cueing should be used to support learners in successfully processing the information and attaining that competence, if we consider cues to be mathemagenic agents that can give birth to learning and positively influence what and how something is learned.

According to Rothkopf (1996), 'instructional events' induce a targeted competence in at least some learners in at least some situations at least some of the time, and three variables determine the inclination to successfully process an instructional event once it has been encountered, namely: (a) disparity between the representation of instructional information and the representation of the targeted competence, (b) persistence of elicited mathemagenic activity, and (c) instruction-relevant experience (and knowledge) of the learner. We recommend cueing to increase the likelihood of competent executions of tasks by providing information about those tasks that resembles the targeted learning processes and -outcomes as closely as possible, and directs and motivates learners to act as they are supposed to. Cueing should (a) not be disparate from the targeted competence, and (b) provide learners with experiences (information, events, happenings) to persevere in attaining that competence.

Cueing and schema construction

Restraining to familiar schemata can inhibit learning and result in surface processing of information instead of deep, meaningful processing. Unfamiliar problems require learners to construct new, more efficient schemata. Chi, Feltovich and Glaser (1981) found that the ability to solve problems is not a sufficient condition for the construction of more efficient schemata. Subjects who solved problems with relative ease were unable to abstract from their solutions the (more general) principles and approaches used in solving these problems. Cueing should focus learners' efforts on these principles (e.g., by driving questions in PW), provide additional information about the solutions (e.g., by explicating relations in WOE), help abstract more general problem-solving approaches, and construct more efficient schemata. In this section we give guidelines for cueing that facilitates the construction of more efficient schemata by (a) reflecting relations between and within tasks, (b) saliently presenting task characteristics, (c) facilitating transfer, (d) optimizing available working memory, and (e) just-in-time presentation.

Cueing should reflect the relations between and within tasks (4). The tasks in multimedia practicals are solved by following SAPs that are valid for more problem situations within the same domain and beyond (Van Merriënboer, 1997). SAPs indicate the relations *between* tasks, and subSAPs indicate the relations *within* steps. The subSAPs in *Preparing a plea* are manifested in a PW for each step, providing information about the principles, concepts, and rules of that specific step. The relations between task characteristics and more general principles are referred to as problem's 'deep structure' (e.g., Dufresne, Gerace, Thibodeau-Hardiman, & Mestre, 1992). These deep structure features embody the relations that exist within the step. For instance, in following the PW for drawing up a pleading inventory you have to answer some questions before being able to move on to the next.

Cueing should saliently present relevant task characteristics (5). For transfer to occur the essential principles of problem's deep structure should be presented to the learner very clearly. Learners should not be left guessing too long which task characteristics should be picked as the most relevant or critical ones, especially in complex tasks where there is a large amount of both relevant and irrelevant or even misguiding characteristics involved. According to Phye (1990) this saliency requirement is more likely to be met when steps are ordered by type and accompanied by cueing that describes the critical features of these steps. For instance, in *Preparing a plea* cueing is ordered in steps for the preparation of a plea and directed at the intended outcomes of these steps (e.g., a pleading inventory after step 3).

Studies of problem categorization (Dufresne et al., 1992) indicate that experts view two problems as similar when the same deep structure features could be applied to solve both problems, whereas novices view two problems as similar when the problems share surface structure features, such as terminology or objects. They argue that this deep structure should be made salient.

Cueing should facilitate transfer (6). Mastering complex skills requires highly variable performance across various situations, far transfer skills for which the desired exit behavior depends on the problem situation. Therefore, cueing should reveal problem's deep structure for a variety of problems. Cueing should highlight the importance of the initial classification of problems, by asking the user to identify the applicable principles and asking to focus attention on concepts and procedures by which principles are instantiated (Chi et al., 1981). We advocate that cueing should be both specific enough to represent all relevant aspects of the (training) task during practice, and at the same time be applicable to a variety of (criterion) tasks within or even beyond the training context.

Cueing should optimize use of working memory (7). Task-valid cueing should be used for (a) optimizing working memory, and (b) improving learning efficiency. Since complex tasks make severe demands on the cognitive capacity of the learners (problems are ill-defined, multi-attributed, have contradicting and misguiding cues, diverging solutions, ...) instruction should be optimized in such a way that working memory is capable of processing information and propagating schema construction at the same time. A brief description of cognitive load theory will explain this.

Working memory load may be affected by (a) the instrinsic nature of the material (causing *intrinsic cognitive load* on the learner), (b) the manner in which the material is presented and learning activities are guided, and (c) the effort invested by the learner (Sweller, Van Merriënboer, & Paas, 1998). *Extraneous cognitive load* is the additional effort required to process poorly designed instruction. *Germane cognitive load* reflects learners' efforts in actual learning that, in particular, contribute to the construction and mindful abstraction of schemata. Instruction should decrease extraneous cognitive load (e.g., by providing cueing that focuses attention) in order to make possible that germane cognitive load can increase (e.g., by providing cueing that offers anchorpoints for the learning task), but only if the total cognitive load stays within limits (treshold working memory load). Redirecting attention from extraneous to germane processes improves the balance between learning efficiency (i.e. cognitive load and schema construction during training), and improved transfer test performance. Several studies have identified guidelines for reducing extraneous cognitive load, but few have focussed on inducing germane cognitive load (Sweller et al., 1998).

Cueing should by presented just-in-time (8). Just-in-time (JIT) presentation of cueing can be effective for (a) optimizing working memory, and (b) improving learning efficiency. Available results on immediate and delayed cueing (e.g., Kulik & Kulik, 1988) need re-examination for more complex and authentic problem-solving tasks. We expect that the 'teachable moment' of such cueing may not so much depend on the information, but on the task characteristics and the stage of task-execution.

According to the 4C/ID-model (Van Merriënboer, 1997), non-recurrent constituent skills require supportive knowledge (heuristics or models) that is best presented *before* practicing sets of interrelated tasks. JIT presentation of supportive information induces schema-based behavior since the learner connects new information to available schemata, making them more efficient. Recurrent constituent skills require prerequisite knowledge (facts, concepts, and principles) that is best activated *during* task practice. JIT presentation of prerequisite information during practice induces rule-based behavior and schema automation. The final purpose of whole task practice in multimedia practicals is schema construction and schema-based behavior, the ability to perform unfamiliar (far transfer) task aspects because of the availability of schemata. The availability of generalized, more abstract schemata is revealed by higher performance on transfer task in new situations.

Comparing PW and WOE

At this point we can take the guidelines provided so far to argue why PW and WOE appear suitable for facilitating schema construction. Both PW and WOE in multimedia practicals are ordered by step and reflect the relations of important task characteristics (guideline 4). However, in PW critical features of steps are presented more saliently (guideline 5).

The demand for transfer (guideline 6) constitutes an optimalization problem between offering PW and WOE, depending on the characteristics of the learner. Novice learners still need the support of more concrete, product-oriented cueing, containing a lot of surface features about the task (e.g., objects and terminology). WOE directly support training practice by providing concrete information about the context, and facilitate the construction of 'rich', descriptive schemata that lead to near transfer on tasks in a similar context, like preparing a plea for another case in the same type of court (and consequently provide less support for far transfer). More expert learners benefit more from more abstract, process-oriented cueing that embodies the ‘deep structure’ of the step (Dufresne et al., 1992). PW provide an approach that is generalizable to a larger variety of tasks, and facilitate the construction of 'broad', prescriptive schemata that lead to far transfer on tasks in another context, like preparing a plea in a different type of court (e.g., criminal vs. civil) outside the training context (and consequently provide less support for near transfer). In Figure 2.2 the relations between cueing, schemata, monitoring and learning outcomes are shown in our model for schema construction (the content of the monitoring-box is explained in the upcoming section).

Both PW and WOE could increase germane cognitive load and decrease extraneous cognitive load at the same time (guideline 7), since they focus learners’ attention on relevant questions and features in the solution and restrain them from searching through irrelevant information. However, the suitable format of cueing depends on the task characteristics: Is the task process- or product-oriented? Does the task require abstract or concrete information?

Finally, both PW and WOE can be provided just-in-time (guideline 8). Timing of cueing depends on task characteristics and stage of execution of the step. PW contain more supportive information, that is best provided before practice. WOE may contain more prerequisite information, which is best provided during practice or after practice (as important input for the next step).

In the next section we consider the role of monitoring in complex learning. Cueing should get monitored in relation to the problem-solving process, and guidelines should also address this process of cognitive monitoring.

Cueing and monitoring

In review studies (Boekaerts & Simons, 1993; Pintrich, 1999) monitoring is considered to be an important predictor of complex learning outcomes. Cueing can facilitate monitoring, leading to more efficient learning and better (more, deeper, more meaningful) learning outcomes. When decribing formats of cueing, each format was considered as a whole. In fact, this cueing always consists of several cues (i.e. several critical features in a WOE or several driving questions in a PW). Each cue is a piece of new information, that should find its place in available cognitive schemata. Every cue gets monitored in relation to the problem-solving process: Is this information new and usable for this problem? Where can this new information be attached to? Should available schemata be modified?

This section describes the internal feedback processes (see Figure 2.2) within the cognitive system that make up this continuous monitoring process. Cognitive monitoring for an important part deals with constantly (for each cue) evaluating and adjusting the adequacy of available schemata (assimilation), and integrating new elements in more adequate schemata (accommodation).

Rumelhart and Norman (1978) distinguish three qualitatively different modes of learning: accretion, tuning and restructuring. In complex learning the first step is the accretion (merely addition) of information in available schemata (similar to Piaget's assimilation) to create a reasonable data-base of knowledge, followed by the construction of new schemata (restructuring) to organize these data structures appropriately (similar to Piaget's accommodation). Then, continued learning consists of further tuning of those schemata (and possibly restructuring of schemata, which in turn have to be tuned). Whether schemata need to be restructured or merely tuned depends on the discrepancy of the arriving cue and the available schemata. If this information is only mildly discrepant, tuning of schemata may be sufficient ; if the information is more discrepant, restructuring of schemata is required.

We now give guidelines for cueing that promotes these monitoring processes by (a) stimulating evaluative questioning, (b) providing information about the progress, and (c) providing information about the intermediate results.

Cueing should induce or provide evaluative questioning (9). Monitoring has to do with constantly (for each incoming cue) questioning the adequacy of available schemata, and cueing should promote this process of continuous evaluative questioning. According to Ertmer and Newby (1996) problem solvers, on the one hand, evaluate by asking themselves *outcome-oriented questions*, like: How reasonable and accurate is the product that resulted from the learning task? To what extent is the goal achieved (already)? Product-oriented formats of cueing (like WOE) are most adequate in supporting this type of evaluative questioning. On the other hand, they also ask themselves more *process-oriented questions*, like: How effective has the overall process been (so far), as well as its supporting steps in achieving the goal (e.g., correctness of used schemata, efficiency of used approaches)? Which obstacles were encountered? How well were they anticipated, avoided, or managed? How effective and efficient is the overall plan? Should it be modified to use with similar tasks in the future? Process-oriented formats of cueing (like PW) are most adequate in supporting this type of evaluative questioning.

Cueing should provide information on how to proceed (10). If learners can link cueing with intermediate achievements, they will feel supported in their monitoring. Cueing should enable learners to examine progress in their problem solving (e.g., Whitehall & McDonald, 1993). For instance, a PW may concern relevant features of the task, but also consecutive questions or steps within the task. Through the use of such PW the learner acquires schemata that enable him / her to reflect on the quality of the problem-solving process. PW provide best support for an evaluation of the *completeness* of used schemata, since learners can check which criteria or questions have been checked or answered during the learning process, while the *correctness* of a solution can best be assessed with WOE.

Cueing should contain information on intermediate stages (11). Cueing should be related to the targeted performances and products. Cueing should not only resemble these outcomes (guideline 3) and provide information about the progress (guidelines 9 and 10), but preferably also contain information about milestones during task execution so that learners can assess (intermediate) solutions at various stages of task execution.

For instance, while ordering documents in a law file (step 1), the correct number of documents in submap 'documents in the case' is (just) one cue that predicts the targeted performance, i.e. a correctly ordered law file. Values for this single cue might be 'there aren't any documents yet', 'about half of the documents is still missing', and 'ordering is nearly done'. Other cues for performance on this task might be the correct (e.g., chronological) ordering within the submap 'documents in the case', the number of correctly filed documents in other submaps, and the ordering of those documents (e.g., correspondence, notes on telephonic or other communication).

Cues can correlate with each other. Each cue alone, and the set of cues together, may predict whether this trainee will ultimately achieve a correctly ordered lawfile.

At the end of the development of *Preparing a plea*, a field trial was carried out with a Beta-release to determine the instructional effectiveness of provided cueing and step size. Students were given the same tasks and version of the multimedia practical, and were questioned about their appreciation of provided cueing. In this Beta-version PW are given at instruction (feedforward), and WOE are given after learner reports have been submitted (feedback).

Method

A small group of sophomore law students (*N* = 12) was selected at random from both the Open University of the Netherlands (OUNL) and the University of Maastricht (UM). The OUNL is an institution offering distance education for a heterogeneous population of students, varying in age of which most have a steady job while studying; this subgroup of 2 male and 4 female students had no plea experience at all). The UM is an institution offering contact education (project-oriented) to 18-23 year old students; this subgroup of 2 female and 4 male students had some plea experience as members of a debating club. The multimedia practical's intention is to be used by students without plea experience.

Learner reports were extracted from the multimedia practical, study times were collected by log files, and pleas were scored and video-taped. Learning reports are filled in process worksheets that had to be sent to the virtual mentor. These (intermediate) products are no obstacles or assessment for continuation. For research purposes however we have extracted them from the program and assessed them. A jury consisting of three persons (two teachers and one trainer) scored students' results on the pleas.

All field-trial students were sent a questionnaire afterwards with a 3 week response period, and the prospect of receiving a video-tape of their plea(s) during the role-play sessions (as was promised during field trial) and a little company present on CD-ROM (as was promised when sending the questionnaire). We received all questionnaires back with no reminder. Data were collected on subjective appreciations of aspects of both step size and complexity of steps, and the timing and orientation of cueing.

Results

Study times, learner reports and pleas

Study times and learner reports of eight participants (equally divided over subgroups) could be collected and analyzed. Study times show large variations, e.g.

on the law file 'Bosmans' they range from 40 to 664 minutes (*M* = 341, *SD* = 134). Means of OUNL-students (*M* = 499, *SD* = 213) and UM-students (*M* = 134, *SD* = 52) differ significantly, with Mann-Whitney's $U = 6.5$, $p < .01$.
Learner reports show that most students followed the SAP and worked their way through consecutive steps, using the PW and WOE provided. Since we didn't require participants to work out and submit intermediate learner reports, this route was taken on a voluntarily basis. The quality of learner reports and pleas was sufficient, according to the assessments of content experts involved. All students completed the multimedia practical successfully and were, according to the jury, able to conduct a plea in court. However, validated instruments to assess the quality of reports and pleas were lacking during the field trial.

Questionnaires

All students report to have been highly motivated (*M* = 3.4, *SD* = .6) and self-confident while preparing the plea (*M*= 2.9, *SD* = .6), and to have appreciated the general setup of the program. Male participants report significantly more self-confidence during study than female participants ($U = 10$, $p < .05$), while OUNL-participants are less confident than UM-participants ($U = 12$, $p = .09$) (but about equally motivated). Students' mean scores on items on cueing are listed in Table 2.2.

Table 2.2: Students' (N = 12) appreciations of relevant items (abbreviated) in the questionnaire

Items		Scale	*M*	*SD*
1.	Motivational level at work	[1 (low) – 4 (high)]	3.4	0.6
2d.	SAP not necessary to hold plea	[1 (disagree) – 4 (agree)]	2.4	1.1
5.	Confidence level at work	[1 (little) – 4 (much)]	2.9[a]	0.6
6.	Information (in general) is helpful	[1 (little) – 4 (much)]	2.5	0.9
7a.	Timing of PW	[1 (inadequate) –2 (adequate)]	1.9	0.3
7b.	Timing of WOE	[1 (inadequate) –3 (adequate)]	2.7	0.6
8a.	WOE helpful for understanding	[1 (disagree) – 4 (agree)]	2.9	0.8
8b.	WOE helpful for executing	[1 (disagree) – 4 (agree)]	2.8	0.6
8c.	PW helpful for executing	[1 (disagree) – 4 (agree)]	2.9[b]	0.6
8d.	PW helpful for understanding	[1 (disagree) – 4 (agree)]	3.0[b]	0.7
9a.	WOE helpful during study	[1 (disagree) – 4 (agree)]	3.1	0.7
9b.	PW helpful during study	[1 (disagree) – 4 (agree)]	2.7	1.0

[a] With UM-students scoring significantly higher than OUNL-students

[b] With OUNL-students scoring significantly higher than UM-students

Students report that information (in general) was helpful (M = 2.5, SD = 0.9) while studying. Timing of cueing was considered adequate both for PW (M = 1.9, SD =0.3) and WOE (M = 2.7, SD = .61). Both PW and WOE were found helpful while executing steps (M = 2.9, SD = .61 and M = 2.9, SD = .83), for understanding the executed steps (M = 3.0, SD = .68 and (M = 2.8, SD = .58), and during study (M = 2.7, SD = .95 and M = 3.1, SD = .66).

OUNL-students value cueing more across all items, and significantly more on 'helpfulness of PW in executing a task' (U = 10, p < .05), and 'helpfulness of PW in understanding the task' (U = 8, p < .05). This significant difference is confirmed by negative (Spearman's Rho) correlations between institution and appreciations on these items, $r_S = -.59^*$ and $r_S = -.66^{**}$ respectively. For WOE no significant correlations were found.

Other significant inter-correlations were found between (data omitted in the following text, are given in Table 2.3): Item 6 with items 8c, 8d, 9b, and 2d ($r_S = .56^*$) indicating an overall appreciation for PW; Item 8c with item 2d ($r_S = .66^{**}$), indicating an appreciation for SAP (for the execution of the task) and PW (for the execution of steps) as an interrelated whole; Items 8c, 8d, 9a, and 9b, indicating consistency between these cueing scores; and Item 9a with two items pertaining the complexity of steps (pleading inventory and pleading note), with $r_S = .74^{**}$ and $r_S = .88^{**}$ respectively, indicating that students feel especially supported by WOE when cases get complex.

Table 2.3: Inter-correlations (Spearman's Rho) between some relevant items on cueing (N = 12)

Items	6	8a	8b	8c	8d	9a	9b
6. Information (in general)	_						
8a. WOE for understanding tasks	.46	_					
8b. WOE for executing tasks	.47	.39	_				
8c. PW for executing tasks	$.65^*$	.31	.12	_			
8d. PW for understanding tasks	$.65^*$	.27	.16	$.92^{**}$	_		
9a. WOE during study	.23	.28	.22	$.60^*$	.52	_	
9b. PW during study	$.74^{**}$	.31	.04	$.95^{**}$	$.89^{**}$	$.56^*$	_

* $p < .05$

** $p < .01$

Concluding, students enjoyed working through the multimedia practical and appreciated the general setup of the program with the cueing as was provided. The quality of learner reports and pleas appears to be sufficient. These findings show (1) that the cueing developed according to our model is highly valued and appears effective, which gives tentative support for the use of task-valid cueing and combined use of PW and WOE in multimedia practicals. In regard to the two subgroups, it appears (2) that confidence gives students reason to believe that tasks are less complex and can be studied in less time, and in a more self-regulated fashion, with less need of externally provided cues, like PW. Since OUNL-students are more accustomed to a system of self-guided study and material, in which embedded support devices are incorporated, the difference in appreciation might also be attributed to unfamiliarity. Finally, (3) interesting relations were found between students' appreciation of the SAP (for the execution of the task) and PW (for the execution of steps), and between reported complexity of steps and helpfulness of WOE.

Discussion

Multimedia practicals can be aimed at competences in solving a variety of problems beyond the direct context of the multimedia practical. These complex skills require schema-based behavior, which should be facilitated and monitored by providing task-valid cueing. Our main instructional hypothesis is that demonstrating a 'goal competence' requires the combined application of both automated schemata for recurrent aspects, and more general schemata for non-recurrent aspects. A combination of both WOE and PW in instruction therefore appears most suitable to facilitate schema construction in a variety of tasks. Both formats have been studied from the perspective of the 4C/ID model (Van Merriënboer, 1997), and in relation to cognitive load theory (Sweller, 1988), and have appeared suitable in complex learning.

Findings from a study on the appreciation of the multimedia practical *Preparing a plea* indicate that a combination of PW and WOE indeed guides and promotes competence-based learning. Based on these preliminary data, we assert that process-oriented PW contribute to cognitive schema construction *during* the execution of (complex) steps, that process-oriented SAPs are helpful in following a meta-cognitive strategy *during* task execution, and that product-oriented WOE are of most value for understanding task execution *afterwards*. Our students reported that the presence of both process- and outcome-oriented cueing has led to better performances (pleas) and more focused information searching (while preparing the plea), as was found earlier (e.g., Earley, Northcraft, Lee, & Lituchy, 1990; Johnson, Perlow, & Pieper, 1993).

Relations between cueing, schemata, monitoring and learning outcomes were depicted in a model for schema construction. Guidelines on adequate cueing were presented throughout the article, and provide us with an evaluative framework.

PW and WOE were described in more detail as possible formats of task-valid cueing and could be evaluated with these guidelines on their suitability to facilitate schema construction. However, our model needs thorough empirical testing. Further research was therefore conducted to justify our assertions and improve the model and guidelines. The most important questions we addressed deal with when and how cueing should be provided in authentic problem-solving tasks. These questions will be examined in the upcoming chapters that describe our experimental studies.

Cueing should not be studied from the level of specific steps (in-step operations) alone, but also in relation to the task-as-a-whole. Nadolski et al. (2001) present an ID-model that addresses the issues of task decomposition and step size in relation to cueing in multimedia practicals. In the design phase of their two-phase six-step model, variability of practice is suggested through a combination of WOE and problems accompanied by PW. A study examining the benefits of both WOE and PW on learning and transfer outcomes will now be reported next (Chapter 3).

Relations between the aspects of timing and orientation of cueing on one hand, and learner- and task characteristics in competence-based learning on the other hand, is an interesting issue to be clarified further. For instance, moving from novice to expert, learners can be confronted more with PW and less with WOE. Having control over timing and formats of cueing may help learners optimize their allocation of cognitive resources. A study examining the benefits of timing of cueing on learning and transfer outcomes will be reported in Chapter 4.

CHAPTER 3 – **Cueing for transfer***

Abstract

In this chapter we investigate the effects of cueing, in a multimedia practical for the individualized training of the 'whole task' to prepare a plea, on the learning outcomes of 43 sophomore law students. The cueing formats of worked-out examples (WOE), process worksheets (PW), and both WOE / PW, are compared to a no-cueing control condition. Our hypotheses that WOE enhance near transfer, by stimulating imitation processes to similar tasks, and PW foster far transfer, by stimulating mindful abstraction processes to different tasks, were partly confirmed by learning outcomes on the training task and two transfer tasks.

Cueing for transfer in multimedia practicals: Process worksheets versus worked-out examples

Mastering complex problem-solving competences is the ultimate goal of higher education. *Competence* can be defined as the whole of knowledge and skills which people have at their disposal and which they can efficiently and effectively use to reach certain goals in authentic situations (Kirschner, Van Vilsteren, Hummel, & Wigman, 1997). Although the importance of solving authentic problems is recognized in professional practice, it is not sufficiently acknowledged or articulated in the Instructional Design literature. This was recognized in the previous chapter that presented guidelines for effective cueing in competence-based training. This chapter presents a study examining the effects of cueing formats in a multimedia practical from the domain of Law training the competence to prepare a plea.

The problem solver's understanding of the problem, the initial problem state, intermediate states and goal state, along with the operators for moving from one to the other, is known as the *problem schema* (Wood, 1983). *Cueing* is defined for this study as a possible instructional technique to facilitate the interpretation and construction of problem schema to enable *transfer* in solving similar problems (near transfer) and not similar but related problems (far transfer). This near / far distinction in transfer is closely related to the issue of context-dependent versus context-independent strategies in programming (Perkins & Salomon, 1989). We must note

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* Based on: Hummel, H. G. K., Paas, F, & Koper, E. J. R. (2004). Cueing for Transfer in Multimedia Programmes: Process Worksheets versus Worked-out Examples. *Journal of Computer Assisted Learning, 20*(5), 387-397.
The data of this chapter were presented in a paper presentation at the 10th Biennial EARLI-conference in Padova, Italy (August 26-30, 2003).

that this concept of similarity is relative to its context: within the domain of Law, to transfer a pleading competence from civil to criminal law will be considered as far and not similar; within the domain of oral communication as near and similar.

Instructional guidelines and empirical data on effective cueing formats in competence-based learning are sparse, and techniques to facilitate schema-based learning have primarily been studied in contrived learning situations with relatively short, well-structured and self-contained tasks (Mory, 1996). Balzer, Doherty and O'Connor (1989) show that so called task-valid cognitive feedback improves *learning* to monitor the adequacy of available schemata, and to construct more efficient schemata. Other researchers (e.g., Narciss, 1999; Whitehall & MacDonald, 1993) show positive effects of this cueing on recall and interpretation of available schemata; a larger amount of task-valid information leads to more effective *performance* on related tasks.

Problem schema

Problem-solving expertise heavily depends on the presence of knowledge structures that wrap up numerous information items as single items organized in a way to be widely used, often referred to as schemata (e.g., Chi, Glaser, & Rees, 1981). Where novices have to rely on superficial similarities between concrete problems (e.g., Sweller, 1988), experts have learned more structural problem schema that categorize and solve various problems (Chi, Feltovich, & Glaser, 1981). According to schema-based learning, learners actively recall and interpret old schemata and construct new schemata in light of new information or cues. Schemata enable us to recognize a problem as a member of a class (e.g., a civil law case) and find a procedure appropriate for *all* problems of that class. Using a problem schema or finding analogies in new problem situations (e.g., a criminal law case), is the key to *transfer* and the ability to apply training problems to everyday and professional problems (e.g., for lawyers to hold effective pleas for *various* law cases, and not just for the ones they were trained for).

Task-valid cueing

Pellone (1991) explains the difference between feedback, reinforcement and cueing from behavioral learning theory. He argues that students should always be told whether they have given the right answer (feedback), be praised for giving a correct answer (positive reinforcement), or prompted when they need more information (cueing). Cueing is often equated with domain-independent, generic or reflective prompting, like in comprehension gauging questions (Chi et al., 2001) or the Leittext method (Koch & Selka, 1991; Teurlings, 1995). Learners are then provided with domain-independent judgement prompts or driving questions (Land, 2000), like:

"Do you understand the assignment?", "Are you sticking to your initial working plan?" or "Didn't you overlook something?". In this thesis, task-valid cueing is operationalized as *domain-related content prompting or -hinting*, containing information about the attributes of multi-attribute objects of judgements in complex problem-solving tasks in a specific domain. Schemata represent the relations within and between these objects.

Two formats of task-valid cueing

A whole task or case type (Van Merriënboer, 1997), like preparing a plea, is made up of specific steps that learners will subsequently work on for each case of that type. Both concrete, more product-oriented cueing and abstract, more process-oriented cueing are needed for schema-based learning in each step. *Product-oriented* formats pay no attention to the general characteristics of problem-solving process itself, but only involve specific given states, goal states and solutions. Worked-out examples (WOE) focus learners' attention on *concrete* problem states and associated operators, enabling them to interpret and select existing schemata and *induce* more generalized solutions. *Process-oriented* formats pay attention to the problem-solving process by providing *general* strategies and heuristics, enabling learners to construct or adapt schemata and *deduce* a specific solution. Process worksheets (PW) contain a layout with keywords or driving questions (Land, 2000) reflecting a strategic approach. Ley and Young (2001) suggest for individualized learning to combine evaluation criteria as a quality control checklist (like a PW) during assignment preparation and later provide assignment evaluations (like a WOE) based on the same criteria. The previous chapter introduced PW and WOE as cueing formats; the next sections will now extend that description. The multimedia practical *Preparing a plea* (Wöretshofer et al., 2000) requires law students to learn and demonstrate the 'whole task' of preparing a plea to be held in court (see Figure 2.1 for an impression). For this study, we asked participants to learn to prepare the plea while varying the availability of the PW and WOE cueing formats.

Process worksheets

In the social and liberal arts domains it often is difficult to objectively decide on the best solution for a complex problem. What can best be established is a systematic approach to the problem (SAP) in general, with possible steps to reach a solution. We expect PW to structure learning sequences and identify important concepts for learners *in a variety of situations*, directly relevant for the construction and mindful abstraction of schemata. PW are expected to be most effective for expert learning outcomes on process-oriented tasks, like drawing up a pleading inventory, where the search for relevant legal information is structured by driving questions. Instructional techniques that systematically structure content, such as concept mapping, advance or graphic organizers, previews and structured overview have increased learning outcomes (e.g., Driscoll, 2000; Price & Driscoll, 1987). Catrambone (1996) documented the efficacy of two techniques designed to accentuate discrete subgoals: labels and the visual separation of steps. He asserted that labels serve as cues to chunk a set of steps together and encourage a learner to explain why the steps are grouped together. In their review article Atkinson, Derry, Renkl and Wortham (2000) state that an important instructional principle to support problem solving is to *emphasize the conceptual structure by labeling or segmenting* content. In teaching statistical concepts, Quilici and Mayer (1996) concluded that structure-emphasizing techniques are effective because they demonstrate to students that a reliance on surface features does not work. In *Preparing a plea* many task characteristics have to be considered within each step of the SAP, some of which are interrelated. For each step learners are offered a PW with driving questions, checkpoints or criteria that guide learners in their search for relevant information. As an example, for studying the case to draw up a pleading inventory (step 3 of the SAP), some of the questions in the PW can be found in Figure 3.1.

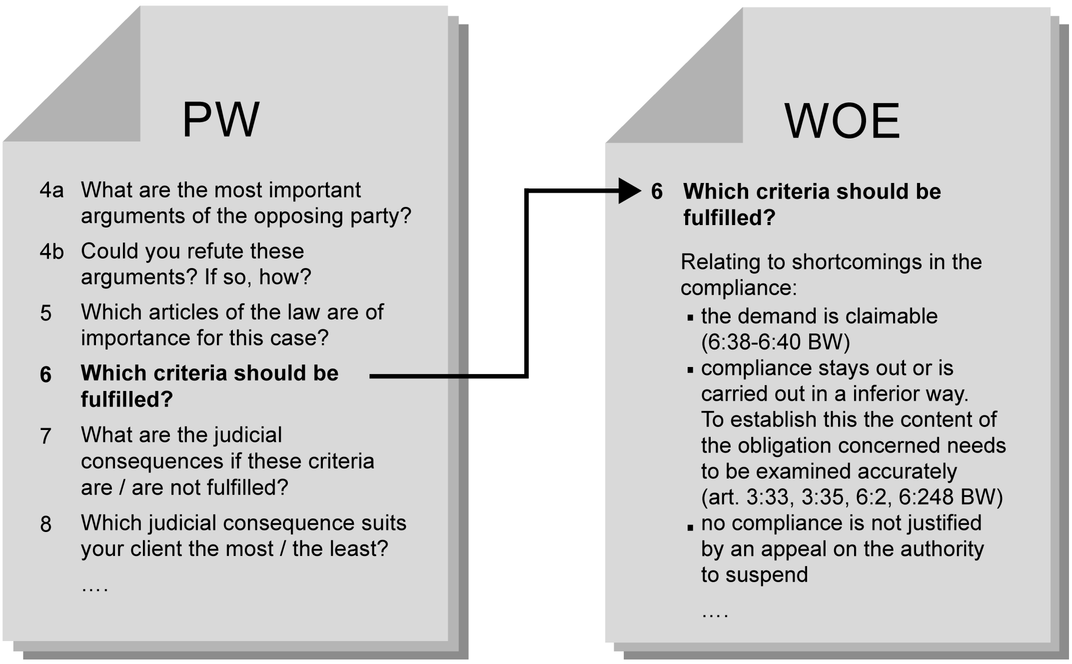

Figure 3.1: Excerpts taken from concrete cueing examples
When studying the file of case X (step 3 of the SAP) students draw up a pleading inventory for case X. Some of thedriving questions that have to considered can be found on the left side (excerpts from the PW); part of the expert solution (i.e. possible answer todriving question 6) can be found on the right side (excerpts from the WOE), with article numbers referring to Dutch Law.

Worked-out examples

The notion of learning by example has been a major theme in educational research for at least the past four decades. We expect WOE to support learners in applying useful problem schemata, to categorize problems with *similar* solutions and find solutions to new problems by analogy to the example. The support of WOE within a training task is expected to increase learning outcomes especially for novice learners and on product-oriented tasks, like writing a pleading note or holding the actual plea, because learners can directly imitate and apply superficial characteristics of examples on products they have to deliver (e.g., making a practical joke at the start of the plea). Atkinson et al. (2000) have stated that important instructional principles to support problem solving are to *employ surface features to signal deep structure*, and to present examples in close proximity to matched training problems. In this study product-oriented WOE are used and operationalized as possible (expert) solutions for specific problem-solving steps, focusing the learner's attention on problem states and associated operators. More process-oriented WOE can also be studied (e.g., Van Gog, Paas, & Van Merriënboer, 2004a) and may foster far transfer, but this cueing format was left out of scope in this study. In several subject domains evidence has been found that studying WOE yields lower extraneous cognitive load, better schema construction, and higher transfer performance than solving the analog problems (Sweller, Van Merriënboer, & Paas, 1998). In *Preparing a plea*, at the end of each step learners can compare their reports with a WOE and see an expert's answers to questions in the PW. As an example, a part (answer to driving question 6) of the pleading inventory (step 3) might look like the WOE in Figure 3.1.

Our first hypothesis is that WOE offer best support (a) for interpreting schemata and inducing a general solution in similar situations (near transfer), and (b) for more product-oriented tasks, since WOE offer concrete product-oriented information that can directly be interpreted. Our second hypothesis is that PW offer best support (a) for constructing schemata and deducing a specific solution in not similar situations (far transfer), and (b) for more process-oriented tasks, since PW offer generic process-oriented information. In the long run we expect PW to have most fundamental effects on schema-based learning, because expert learners focus on mastering deep process techniques and general requirements before focusing on surface characteristics of products and specific outcomes (e.g., Schunk & Schwartz, 1993; Zimmerman & Kitsantas, 1997). For example, experts have learned that to start a plea with a practical joke (a specific solution) will *not always* be the appropriate way to 'get attention from the judge' (a general requirement) *in every* law case.

Method

Participants

At the start of this study, 57 students enrolled in the experiment, organized in the context of the regular court practical they had subscribed to. Students were equally and randomly assigned to four cueing conditions, but due to study planning problems eventually 14 students dropped out. A full dataset on the experimental training and transfer tasks could eventually be collected for 43 students (both PW and WOE, n = 10; PW only, n = 12; WOE only, n = 9; and no cueing, n = 12). These students received the equivalent of about 180 US$ for participation in the experiment. All participants were Sophomore Law students (25 female, 18 male; mean age = 24.12 years, SD = 6.65) studying at two Dutch universities. Since first year law curricula of Dutch universities are practically identical, the students did not differ with respect to domain knowledge. A prior knowledge questionnaire was used to check for possible differences in pleading experience. Analysis of variance revealed that the overall prior presentation skills on an 18-point scale were low (M = 2.88, SD = 2.72) and did not differ as a function of cueing condition (F (3, 39) = .33, MSE = 7.81, p = .81, η_p^2 = .02).

Learning material

An adapted version of the multimedia practical *Preparing a Plea* (Wöretshofer et al., 2000) had to be studied as part of the regular court practical participants had enrolled for. The learning objective of the practical, with an average study load of about forty hours, is to acquire the competence to prepare and carry out a plea in court. The program starts with a non-compulsory task to get acquainted with the program and the stepwise procedure, after which students receive the nine-step whole-task training according to the SAP that was described in Chapter 2 (on pages 18-19). Training consists of one compulsory training task (a civil law case), and two additional non-compulsory training dossiers, before the compulsory transfer task (a criminal law case). The additional non-compulsory training dossiers are available to create a higher variability of practice with the stepwise procedure. Within every step students have maximal freedom of study. For two consecutive steps, the latter always includes cognitive feedback on the former (with expert's WOE of the previous step) as well as a new task instruction (with a PW to support task execution). Each consecutive report can be built on the previous one. For instance, step 3 of the training task (case Bosmans) results in a pleading inventory report: a selection of legal documentation that might be useful for writing a pleading note. Step 6 results in a written pleading note that (according to Dutch Law) has to be submitted to the judge before the lawyer is allowed to carry out the oral plea in court (step 9). Support fades as learners gain more expertise, e.g. the training task (case

Bosmans) contains all nine steps and each of these steps may contain both a PW and a WOE, depending on the condition, while the transfer task (case Ter Zijde) is the same for each condition and contains only one step and no cueing.

Questionnaire and pleading measurement instruments

At the start of the experiment participants received a general prior knowledge questionnaire pertaining to their commitment to the field of law, prior presentation skills, and computer skills. One pleading measurement instrument was developed to measure the quality of the pleading inventory (PI, outcome of step 3). Existing pleading measurement instruments (e.g., Edens, Rink, & Smilde, 2000) can be regarded as too general to be used here. Other instruments measured the learning outcomes of step 6 (PN, pleading note for case Bosmans), and step 9 (PB, the actual training plea for case Bosmans) of the training task, and the transfer plea for case Ter Zijde (PTZ). These three instruments had been used and validated in a previous experiment (Nadolski, Kirschner, & Van Merriënboer, in press). All four instruments were scored by two raters on an average of sixty items that pertain to both legal content and presentation. (Appendix 2 contains the full list of items that was used to score pleading inventory performance on the 'Bosmans' task.) The scores were normalized on 100-point scales. Inter-rater reliability and consistency of these 100-point scales were assessed using intra class correlations (ICC) and Cronbach's alpha. The ICC (3, k) two-way mixed model (Shrout & Fleiss, 1979) for the PI, PN, PB, and PTZ instruments revealed significant average measures of reliability (AMR) of .85, .75, .77, and .64 respectively, with ICC > .70 generally considered to be acceptable (Yaffee, 1998). Cronbach's alpha's for internal consistency of these instruments were .92, .83, .80, and .73 respectively.

Subjective measures on motivation, mental effort, and time-on-task were automatically collected by the program after completing each step of the training task. Mental effort had to be scored on an adapted version of the 9-point scale developed by Paas (1992) to measure the perceived amount of invested mental effort on each step in the training task. The extra time-on-task spent outside the program, together with relevant scores on the questionnaire, was taken to assess motivation (on a 12-point scale). Finally, as all conditions were computer delivered, all participants' actions and study times were logged.

Design and Procedure

Corresponding to a 2 x 2 design (with both PW and WOE being either present or absent) four versions of the practical were developed that only differed for the within-step cueing provided for the training task (case Bosmans). In version 1 (both PW and WOE), participants received a PW with the task instruction at the start of each step and an expert WOE at the end of each step after submitting their own report. In version 2 (PW only) participants received a PW with each task instruction. In version 3 (WOE only) participants received an expert WOE afterwards. In version 4 (no cueing) participants received rather global task instructions without further cueing. Besides this, all versions presented identical support tools, like a 'plea checker' to analyze pleas, discussions of ethical issues in pleading, numerous files and documents, and non-compulsory training dossiers.

Before the start of the experiment the participants were informed, both in a plenary session and by a written instruction and program manual, about the study load (about 40 hours) and necessary prior knowledge and computer skills. Participants were randomly assigned to conditions and were required to work individually. All learning materials, including the written instruction and manual, were sent to the participants' home addresses. Together with the program, participants received the questionnaire, which they had to fill in and return before starting to work on the program. After three weeks, spending approximately 25 study hours, participants were required to hold the plea for the training task (case Bosmans) that was recorded on videotape. About two weeks later, approximately an extra 15 study hours, participants were required to hold the plea for the transfer task (case Ter Zijde), which was also videotaped. The remaining period of the court practical of about nine more weeks was attended in a more regular classroom setting to promote further elaboration and training of the pleading skills. During this extra period again written legal reports were written and delayed transfer pleas were held at the end; results on these outcomes could be collected for 37 participants.

Participants were urged and controlled to work step-by-step, individually and seriously on the reports they had to send in electronically for rating and logging after each plea, and not to discuss anything with fellow students or teachers in order to maintain independence. The individually delivered reports and pleas were controlled for unlikely similarities and possible fraud. The experimenters extracted the pleading inventories and pleading notes, and forwarded these to the raters, who were almost or just graduated law students. This level of legal expertise was sufficient to just establish the presence of all items (an average of sixty items for each instrument); during development of the instruments all items had been predefined and weighed by more experienced law teachers. The raters used the instrument to blindly and independently score reports and videotaped pleas. The legal documents and delayed transfer pleas were about various law cases outside the program, and were assessed by law teachers. An average grade for these reports and pleas was given on a 10-point scale.

Results

Data were analyzed with 2 (process worksheets: present vs. absent) x 2 (worked-out examples: present vs. absent) analyses of variance (ANOVA), with process worksheets (PW) and worked-out examples (WOE) as between-subject factors. Various learning outcomes (on pleading inventory, pleading note, training plea, immediate transfer plea, and delayed transfer plea), various efficiency measures (of the training plea, immediate transfer plea, and overall learning outcome), motivation, mental effort, and time-on-task scores were used as dependent variables. The partial-eta-squared statistic was used as an effect size index where values of .01, .06, and .14 correspond to small, medium, and large values, respectively (Cohen, 1988).

Motivation, mental effort and time-on-task

Differential effects of cueing condition on motivation, mental effort and time-on-task scores were analyzed to control for possible confounding effects on learning outcomes. Analysis of variance of the motivation scores ($M = 4.30$, $SD = 1.85$, on a 12-point scale) reveals that differences as a function of cueing condition ($F(3, 39) = 2.50$, $MSE = 3.12$, $p = .07$, $\eta_p^2 = .16$) could be excluded. Average mental effort scores ($M = 5.12$, $SD = .76$, on a 9-point scale) also do not differ as a function of cueing condition ($F(3, 39) = 1.19$, $MSE = .574$, $p = .33$, $\eta_p^2 = .08$). Finally, (objective) time-on-task logging data on the training task ($M = 894.93$, $SD = 521.97$, in minutes) do not differ as a function of cueing condition ($F(3, 39) = .43$, $MSE = 282{,}006.06$, $p = .67$, $\eta_p^2 = .04$).

Learning outcomes

Logging shows that participants sent in required reports for pleading inventory and pleading note and did not skip steps, and left only 7% of these reports blank. Performance scores on learning outcomes are summarized in Table 3.1.

Table 3.1: Performance on pleading inventory, pleading note, training plea, and transfer plea (N = 43)

	WOE (*n* = 19)				no WOE (*n* = 24)			
	PW (*n* = 10)		no PW (*n* = 9)		PW (*n* = 12)		no PW (*n* = 12)	
	M	SD	*M*	*SD*	*M*	*SD*	*M*	*SD*
Pleading inventory	34.75	21.91	25.67	22.87	23.20	7.91	19.64	10.21
Pleading note	63.80	20.59	54.78	16.28	58.05	15.91	54.95	18.14
Training plea	72.85	9.52	66.28	14.54	60.50	6.07	59.45	15.30
Transfer plea	58.85	5.50	55.17	6.92	55.40	5.35	55.27	7.65

The ANOVA comparing groups that did and did not receive PW and / or WOE on the learning outcomes of the training plea revealed a main effect of WOE (F (1, 41) = 6.36, MSE = 143.90, p < .05, η_p^2 = .15), indicating better outcomes with WOE present. The main effect of PW was not significant (F (1, 41) = 1.00, MSE = 143.90, p = .32, η_p^2 = .03) for these outcomes. The expected main effect for WOE and the main effect of PW on the outcomes of the product-oriented pleading note step were not found (F (1, 41) = .24, MSE = 316.86, p = .62, η_p^2 = .01; F (1, 41) = 1.14, MSE = 316.86, p = .29, η_p^2 = .03, respectively). With regard to the quality of the process-oriented pleading inventory step the expected effect of PW and the main effect of WOE were not significant (F (1, 41) = 1.42, MSE = 280.77, p = .24, η_p^2 = .04; F (1, 41) = .27, MSE = 280.77, p = .61, η_p^2 = .01, respectively). No interaction effects of PW and WOE were found on learning outcomes: training plea scores (F (3, 39) = .53, MSE = 143.90, p = .47, η_p^2 = .01), pleading note scores (F (3, 39) = .27, MSE = 319.55, p = .60, η_p^2 = .01), and pleading inventory scores (F (3, 39) = .27, MSE = 280.77, p = .61, η_p^2 = .01).

Transfer

The expected positive effect of PW on the *immediate* transfer plea, indicating better transfer with PW present, could not be found (F (1, 41) = .86, MSE = 41.61, p = .39, η_p^2 = .02). Both the main effect of WOE (F (1, 41) = .67, MSE = 41.61, p = .42, η_p^2 = .02) and the interaction effect of PW and WOE (F (3, 39) = .76, MSE = 41.61, p = .40, η_p^2 = .02) were not significant.

The ANOVA comparing groups that did and did not receive PW and / or WOE on the *delayed* transfer plea did reveal that students receiving PW (M = 73.16, SD = 4.47) outperformed those who did not (M = 68.61, SD = 7.63; F (1, 35) = 4.41, MSE = 40.59, p < .05, η_p^2 = .15), indicating the positive effect of PW on delayed transfer. The main effects of WOE (F (1, 35) = .15, MSE = 40.59, p = .70, η_p^2 = .00) and the interaction of PW and WOE (F (1, 35) = .13, MSE = 41.61, p = .72, η_p^2 = .00) on these delayed transfer outcomes were not significant. Table 3.2 also shows that transfer scores for those who did and did not receive WOE during training did hardly differ.

Table 3.2: Performance on juridical reports (an average score for a pleading inventory and pleading note) and delayed transfer pleas during the remainder of the court practical (N = 37)

	PW (n = 19)				no PW (n = 18)			
	WOE (n = 7)		no WOE (n = 12)		WOE (n = 7)		no WOE (n = 11)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Juridical reports	65.86	6.47	65.00	6.60	61.14	8.47	61.82	8.93
Closing plea	72.14	5.67	73.75	3.77	68.57	8.52	68.64	7.45

Finally, transfer measures on legal documents written during the remainder of the court practical reveal no significant differences between students who received PW during training (M = 65.32, SD = 6.38) and those who did not (M = 61.56, SD = 8.50; F (1, 35) = 2.28, MSE = 59.37, p = .14, η_p^2 = .06). The main effects for WOE (F (1, 35) = .00, MSE = 59.37, p = .97, η_p^2 = .00) and the interaction of PW and WOE (F (1, 35) = .09, MSE = 59.37, p = .77, η_p^2 = .00) on these outcomes were not significant.

Task efficiency

Efficiency measures are calculated using an extension of the procedure originally described by Paas and Van Merriënboer (1993) for determining instructional condition efficiency. To get insight into the complex relationship between the measures of performance, mental effort, time-on-task and motivation, we extend their instructional condition efficiency measure to a four-factor efficiency measure. In formula: 4 Factor Efficiency (E) = (P-C-T-M) / SQRT (4), with P = Performance, E = mental Effort, T = Time-on-task, M = Motivation, and 4 = number of factors.

Table 3.3: Efficiency measures for training plea, transfer plea, and overall learning outcome (N = 43)*

	WOE (n = 19)				no WOE (n = 24)			
	PW (n = 10)		no PW (n = 9)		PW (n = 12)		no PW (n = 12)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Training plea	.62	.81	.43	1.21	-.19	.65	-.66	1.04
Transfer plea	.51	1.06	.28	.84	-.08	.79	-.57	1.35
Overall learning	.65	.85	.35	.97	-.10	.60	-.64	1.09

* Instructional efficiency measures were calculated using mental effort (E), time-on-task (T), motivation (M) and performance (P). First scores on these variables were transformed to z-scores. The grand mean is used for calculation, through which the mean z score for every condition can be determined. These mean z-scores (can not be graphically represented) form a four-dimensional coordinate system. The relative condition efficiency is calculated as the perpendicular distance from a data point in the coordinate system to the line P = (E+T+M). Calculation of E is done, per participant, with the following formula:

$$E = \frac{\text{Performance - mental Effort - Time-on-task - Motivation}}{\sqrt{4}}$$

Equal performance (P) and (E+T+M) scores yield an instructional efficiency of zero, a neutral score. When P > (E+T+M), the instructional material is efficient because (E+T+M) is lower than might be expected on the basis of observed performance. When P < (E+T+M), the material is not efficient because (E+T+M) is higher than might be expected on the basis of observed performance.

Table 3.3 further explains this formula and summarizes the efficiency measures for the training plea, the transfer plea, and the overall learning outcome, which is the mean score for both training steps and plea.

The ANOVA comparing groups that did and did not receive PW and / or WOE reveals main effects for WOE on both the efficiency of the training plea (F (1, 41) = 10.69, MSE = .89, p < .01, η_p^2 = .22), on the efficiency of the immediate transfer plea (F (1, 41) = 4.90, MSE = 1.11, p < .05, η_p^2 = .11), and efficiency of overall learning outcome (F (1, 41) = 9.68, MSE = .81, p < .01, η_p^2 = .20), indicating higher efficiency with WOE present. No significant main effects for PW (F (1, 41) = 1.31, MSE = .89, p = .26, η_p^2 = .03, F (1, 41) = 1.20, MSE = 1.11, p = .28, η_p^2 = .03, and F (1, 41) = 2.23, MSE = .81, p = .14, η_p^2 = .05 respectively) or interaction effects for PW and WOE (F (1, 41) = .21, MSE = .89, p = .65, η_p^2 = .00, F (1, 41) = .16, MSE = 1.11, p = .70, η_p^2 = .00, and F (1, 41) = .18, MSE = .81, p = .67, η_p^2 = .00 respectively) on these efficiency measures were found. No efficiency measures could be obtained for the delayed transfer plea, since mental effort, time-on-task, and motivation were not measured during the remainder of the court practical.

Discussion

We compared the effects of process-oriented worksheets and product-oriented examples in a multimedia practical in the domain of Law, training the competence of preparing a plea. Our *first hypothesis* was that novice learners would benefit more directly from concrete worked-out examples, which contain a lot of surface features about the task. WOE are supposed to facilitate the interpretation of 'rich', descriptive schemata that enable near transfer on tasks in a similar context, like preparing a plea for another civil law case, and to support product-oriented steps. This hypothesis could be partially confirmed. A near transfer effect of WOE could indeed be confirmed by higher scores on the training plea, as well as by higher efficiency scores on the training plea. However, participants receiving WOE did *not* draw up better pleading notes (a product-oriented step) than those who did not.

Our *second hypothesis* was that more expert learners start to benefit from more general, process-oriented driving questions, which embody the ‘deep structure’ of the task (Dufresne et al., 1992). PW are supposed to facilitate the construction of 'broad', prescriptive schemata that enable far transfer on tasks in another context, like preparing a plea for a criminal law case. This hypothesis could be partially confirmed. Contrary to our expectations, neither a transfer effect of PW on the immediate transfer plea (after two weeks) nor on pleading inventory (a process-oriented task) outcomes during training could be found. Participants receiving PW did not draw up better pleading inventories (a process-oriented step) than those who did not. We did find a far transfer effect for PW on the pleading scores on a delayed transfer plea (after eight weeks). Participants receiving PW during training in the long run (i.e. after a longer training period) appear to hold better pleas for other cases. It should be noted that it is unclear which proportion of the difference on the delayed transfer plea can be attributed to case-type (both transfer pleas were about non-civil law cases) and which to delay (elapsed time for retention). The main question that immediately pops up after finding this mixed far transfer result about PW is: Why did we only find a transfer effects of PW after two months of training, and not after two weeks already? There are a number of possible explanations that require further study.

First, high *variability of practice* is an essential element for far transfer to occur (e.g., Paas & Van Merriënboer, 1994). The beneficial aspects of PW may only become apparent when students have applied them on a sufficiently large variety of law cases and had ample time to let these problem schema mature or 'sink in' during the court practical. If a high level of schema automation is desired for particular routine aspects, the training task alone may not provide enough practice to reach this level because the responsible learning process, strengthening (Anderson, 1983), requires large amounts of repetition. Although additional task training (two additional non-compulsory training dossiers within *Preparing a plea*) was available, logging shows that only few students made use of it. However, the minority of participants (7 of 43) that did spend more than the average time (M = 27.49; SD = 75.54, in minutes) on these non-compulsory training 'dossiers', did draw up better pleading inventories (t (42) = 3.50, $p < .01$ (two-tailed)) and had higher overall learning outcomes (t (42) = 2.08, $p < .05$ (two-tailed)). These differences could not be attributed to cueing condition (F (3,39) = .49, MSE = 5921.10, p = .69, $\eta_p^2 = .04$).

Second, performance scores on the pleading inventories of the training task indicate a very result-oriented (or product-oriented way) learning attitude of participants. Product-oriented WOE can then be expected to provide best support. Students seem '*calculated learners*' who only want to invest time in products that will get graded, and not in the preparatory, more process-oriented tasks, which could eventually lead to better learning products in the long run. We did advise participants to take all intermediate documents (like the pleading inventory) seriously, but they knew these would not get graded. Scores on pleading inventory (M = 25.35, SD = 16.76), which students do not consider a necessary outcome, and pleading notes (M = 57.35, SD = 17.69), which is required to hold a plea, are positively correlated ($p < .01$). This indicates that the quality of a pleading note does improve with the quality of this preparatory step, although generally students don't seem to take preparation very seriously when it does not get graded. Scores for pleading inventory and pleading note differ dramatically, which is confirmed by a t-test (t (42) = -11.82, p < .01, two-tailed). Apparently, only the tail wags the dog, which impression was confirmed by several staff members of court practicals in the Netherlands. Since students across *all* conditions scored poorly on the pleading inventory, it is hard to find a beneficial effect for PW here.

Third, the *timing of cueing* formats was not taken into consideration in this study. According to ID models, like 4C/ID (Van Merriënboer, 1997), procedural information ('how to' instructions, such as driving questions in a PW), that is necessary to perform the consistent, routine aspects of learning tasks (like a pleading inventory) should be made available in time. Procedural information is best presented 'just-in-time' on learner demand during training, and not 'just-in-case' at the start of training the steps (as was the case for this study). Our study adding learner-control to cueing (see next chapter) clearly shows that this extra quality further increases effects of cueing on learning outcomes on both the training and transfer task.

Finally, this study makes clear that further research on task-valid cueing in *authentic learning environments* is timely and promising. Although it does require extra organizational effort and time to conduct such real world research (Robson, 2002), the findings show that instructional techniques to facilitate schema-based learning can be reliably compared in controlled authentic settings with training tasks of longer duration. It appears feasible to study competence-based training with relatively long, ill-structured and realistic problem-solving tasks, which are directly transferable to professional practice. The instructional method to combine product-oriented WOE to support near transfer and process-oriented PW to support far transfer has been applied in multimedia practicals in a variety of domains. We hope that results of this study can be further examined and extended to other domains that share the same type of problem-solving ontology as for Law (i.e. one based on heuristic rules and checkpoints, rather than on strict algorithmic rules and procedures). It remains uncertain if results can be replicated in domains with dissimilar ontologies.

CHAPTER 4 – **Timing of cueing***

Abstract

Task-specific cueing formats that promote the automation and construction of problem solving schemas should ideally be presented just in time to students learning to solve complex problems. This chapter reports experimental work comparing learner-controlled cueing, system-controlled cueing, and no cueing among 34 sophomore Law students in a multimedia practical aimed at learning to prepare and hold a plea in court. The cueing consisted of a combination of process worksheets (PW) and worked-out examples (WOE). Our main hypotheses that participants with cueing would outperform those without cueing and that participants with learner-controlled cueing would outperform those with system-controlled cueing, are largely confirmed by the learning and transfer outcomes on a training and transfer task.

Timing of cueing in complex problem-solving tasks: Learner versus system control

Mastering complex problem solving in authentic situations is the ultimate goal of higher education. The previous chapter demonstrated that multimedia practicals could provide authentic training to acquire complex skills such as diagnosing diseases, searching literature, modeling stress-factors that cause burnout, or preparing a plea in court. These programs are assumed to support learners in interpreting and constructing problem schemas for transfer of these complex problem-solving skills to other problems. This chapter will now examine *cueing* as an instructional technique to facilitate the interpretation and construction of a problem schema to enable problem-solving transfer to related problems. Before addressing the issue of learner control, we will now first extend our descriptions of 'whole tasks' for competence-based learning and cueing formats that facilitate this. Finally, this chapter will report some preliminary findings on the 'teachable moment' for procedural knowledge.

'Whole tasks' and cueing formats

The general opinion among educational researchers (e.g., Hannafin, Land, & Oliver, 1999; Jonassen, 1999; Mayer, 1999) is that *transfer-oriented learning* can best be achieved through the use of 'whole tasks' consisting of a task description, an

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authentic environment and task-valid cognitive feedback (or cueing) to carry out the task. Part-task approaches are rooted in behavioral psychology and teach learners only a limited number of constituent skills at the same time, gradually adding new constituent skills to practice. Part-task practice is most suitable for complex skills when little coordination between constituent skills is needed. Whole-task approaches are rooted in cognitive psychology and teach learners all constituent skills at the same time, gradually increasing the complexity of the context. Whole-task practice is most suitable for complex skills that require the coordination of constituent skills within 'authentic' cases. Whole tasks that have been developed within multimedia practicals typically have a well-defined begin state, many possible pathways, not a well-defined end state, and well-defined constraints. The task itself can be practiced as a whole, provided that the necessary support is given to the learners. Realistic whole tasks typically have a study load of more than 10 hours and need to be segmented into smaller task assignments, or steps. Segmentation offers a Systematic Approach to Problem solving (SAP) for the whole learning task. Nadolski, Kirschner, Van Merriënboer and Hummel (2001) have claimed that task-valid cueing has to be provided for each of the consecutive steps in this problem-solving approach.

In *Preparing a plea* (Wöretshofer et al., 2000), that was adapted for this study, students are offered a SAP consisting of nine steps to prepare a plea. Some steps are more *process-oriented*, like drawing up the pleading inventory by selecting main legal argumentation, other steps are more *product-oriented*, like drawing up and finalizing the pleading note. Both product-oriented cueing in the form of worked-out examples (WOE) and process-oriented cueing in the form of process worksheets (PW) have been identified as important for schema-based learning (e.g., Earley, Northcraft, Lee, & Lituchy, 1990). Concrete, more product-oriented and abstract, more process-oriented cueing formats are both needed for schema-based learning in each step.

In the context of cognitive load theory, the logic is that by using PW to stimulate schema automation for the recurrent aspects of the task, more memory resources become available to deal with the non-recurrent aspects of the complex skill as presented in more specific WOE. Just-in-time presentation of cueing aimed at schema automation therefore is also considered beneficial for schema construction (Kester, Kirschner, & Van Merriënboer, 2001). The twofold purpose of whole task training is the construction of schemata that allow learners to learn unfamiliar task aspects (schema-based behavior, supported e.g. by WOE) and the automation of schemata that allow learners to effortlessly perform familiar task aspects (rule-based behavior, supported e.g. by PW) in other situations.

Product-oriented formats pay no attention to the general characteristics of the problem-solving process itself, but only involve specific given states, goal states and solutions. Worked-out examples (WOE) focus learners' attention on *concrete* problem states and associated operators, enabling them to interpret and select existing schemata and *induce* more generalized solutions. *Process-oriented* formats pay attention to the problem solving process by providing *general* strategies and heuristics, enabling learners to construct or adapt schemata and *deduce* a specific solution. PW may contain a layout with keywords or driving questions (Land, 2000) reflecting a strategic approach. Ley and Young (2001) suggest a combination of evaluation criteria in a quality control checklist (like a PW) during assignment preparation and later provide assignment evaluations (like a WOE) based on the same criteria for individualized learning. The multimedia practical *Preparing a plea* (Wöretshofer et al., 2000) requires Law students to learn and demonstrate the 'whole task' of preparing a plea to be held in court (see Figure 3.1, on page 38, for concrete examples of PW and WOE, and Figure 2.1, on page 19, for an impression of the practical). We asked participants to learn to prepare the plea while varying the availability and learner control over the PW and WOE cueing formats.

In the research literature hardly any guidelines on efficient formats and timing of cueing in realistic whole tasks can be found. Chapter 3 presented the results from a study comparing worked-out examples (WOE) and process worksheets as possible formats of within-step cueing. The results of this study suggest that WOE and PW can be used to promote near and far transfer respectively. This chapter presents the results from a study designed to investigate if these cueing formats can best be presented at fixed (instructor-determined) moments, i.e. system-controlled, or upon learner's demand, i.e. learner-controlled.

Learner versus system control

In most multimedia practicals within-step cueing is provided at fixed moments, determined by the 'instructor'. For example, in *Preparing a plea* the PW are provided together with the instruction for each step and WOE at the end of each step. Learner control has become an important instructional issue, and refers to the extent to which trainees can time and use feedback (but also method and practice) in training. It has been suggested (Ford, Weissbein, Smith, Gully, & Salas, 1998) that learners become more engaged and motivated when they are (or perceive to be) in charge of these portions of training, and can more actively adapt the training to meet their needs. Key dimensions that may influence feedback effectiveness include the need for more elaborative feedback (providing cueing to guide the learner in complex tasks), adapting feedback to individual learner characteristics, and the timing of feedback (Mason & Bruning, 1999; Morrison et al., 1995). Amongst others, Kay (2001) and Renkl (2002) have shown that giving learners more control and responsibility over their learning process, e.g. over using supportive tools and instructional explanations, offers promising possibilities for improved and more adaptive learning. In addition, cognitive load research has shown that learners are able to monitor their cognitive load, and to use this information for decisions about the need to reduce or increase the complexity of learning tasks (e.g., Paas, Renkl, & Sweller, 2003).

Generally speaking, there are two views with regard to timing of information presentation (e.g., Kester, 2003). According to the educational view, information that is relevant to the acquisition of a skill should be presented *before* practicing the skill. According to the psychological view, information should be presented just-in-time, on learner demand, that is *exactly when needed* during the acquisition of a skill. In the 4C/ID-model for instructional design (see Van Merriënboer, 1997) a distinction is made between: *procedural*, more rule-based, more process-oriented or 'how to' knowledge; and *supportive*, more product-oriented or 'what to' knowledge. In contrast to declarative knowledge, procedural knowledge is goal specific and deals with how to attain goals in an effective way, given certain circumstances. According to the model procedural information should be provided *just-in-time* to enable the acquisition of more general *recurrent* aspects of the complex skill, which can be traced back to specific steps. Supportive knowledge is declarative knowledge that is relevant for the acquisition of more specific *non-recurrent* aspects of the complex skill, which often can't be traced back to specific actions, and should be provided before consecutive steps. Kester (2003) demonstrated that the search behavior with the 'supportive before, procedural during' information presentation format was most effective, using practice problems from the domain of physics (i.e. electrical circuits). She explains that, when task complexity does not cause cognitive load to overflow, timely provided procedural information can be directly activated in working memory when necessary for performing the learning task. However, in Kester's studies the timing of supportive and procedural knowledge was also determined by an 'instructor', thus system-controlled.

A recent review of feedback research (Mory, 2003) has shown that 'time control' is an important issue and that most of the studies examining the issue so far have used small, contrived, experimental learning tasks, such as list learning, stemming from an objectivistic paradigm. For instance, a review study by Hamaker (1986) on the timing of higher-order, comprehension adjunct questions demonstrated that the widely accepted general facilitative effect of adjunct questions is not general at all. In his review both 'backward effects' (to review material that has been questioned) and 'forward effects' (to develop a set to attend to the information that will be questioned) of certain adjunct questions were found. Hamaker (1986) further established *time control* as a major design feature that may not only determine the size of adjunct questions effects, but also the way in which the pattern of learners' processing activities is changed. As a general result, Kulik and Kulik (1988) in their meta study on feedback found immediate cueing to be more effective than delayed feedback. On the other hand, other studies showed *delay-retention effects* (see e.g., Clariana, 2000; Kulhavy & Anderson, 1972; Schroth, 1992), which were explained from various learning hypotheses, like: interference-perseveration (Hannafin & Reiber, 1989; Kulhavy & Stock, 1989); frequency of feedback (Kulik & Kulik, 1988); guidance (Lewis & Anderson, 1985; Schmidt et al., 1989); and from the mathemagenic perspective (Landauer & Bjork, 1978; Robins & Mayer, 1993).

It has been argued before (e.g., Derry & Lesgold, 1996; Van Merriënboer & Sweller, 2003) that these findings and explanations on timing of cueing are now in need of re-examination in more authentic contexts and highly interactive environments, where learners must receive or actively seek information to carry out more complex tasks within training programs of longer duration. We expect that the 'teachable moment' of cueing may not only depend on task characteristics (e.g., more descriptive or more prescriptive content), but even more so on the characteristics of the individual learner. Therefore, we assume that the ideal moment to present information can only be determined by learners. This hypothesis is examined in the present study by using learner-controlled cueing in authentic, schema-based learning situations, where supportive knowledge is thought to promote schema construction, and procedural knowledge to promote schema automation. In line with our previous findings (see Chapter 3), we expect that participants receiving cueing will outperform participants not receiving cueing on training and transfer tasks. In addition, we expect that learner-controlled cueing will lead to higher training and transfer performance than system-controlled cueing.

The 'teachable moment'

We hypothesize that process-oriented cues, i.e. PW, will especially foster learning performance on more process-oriented steps during training (e.g., pleading inventory), and on transfer task performance (far transfer). We hypothesize that product-oriented cues, i.e. WOE, will especially foster performance on intermediate product-oriented steps (e.g., pleading note) during training, and on pleading performance within the training task (near transfer). As was argued before, learner's control over supportive information is not considered crucial, but learner's control over procedural information is considered crucial. As a secondary aim of this study, we examine some more qualitative logging data on what will be the 'teachable moment' (when exactly is 'just-in-time'?) for providing PW. Will this moment be immediately upon task instruction, after 5, 10, 20, …percent of the time-on-task, or just a little before completion? We have examined what students in demand consider the right moments for looking into and filling in the PW, since learner's control is especially important for procedural support. We expect participants receiving PW at fixed moments to immediately look and use them after that moment, while participants that are in control will pick their own moment before or after. More specifically, we expect students to postpone the use of PW till a moment during task execution they see fit.

Method

Participants

Forty students enrolled in the experiment and were assigned to three experimental conditions in a randomized controlled trial. A full dataset could eventually be obtained of 34 students (learner-controlled cueing condition, $n = 12$; system-controlled cueing condition, $n = 12$; and no cueing condition, $n = 10$). Students received the equivalent of about 100 US$ for participating. The participants were Law students (22 female, 12 male; mean age = 23.26, $SD = 5.22$) in their third year of study at a Dutch university. Comparability of pleading experience was assured by a prior knowledge questionnaire. A One-Way ANOVA revealed that the overall prior presentation skills on an 18-point scale were low ($M = 3.47$, $SD = 2.73$) and did not differ as a function of experimental condition (F (2, 31) = 0.19, $MSE = 7.95$, $p = .98$, $\eta_p^2 = .00$). An extra, fourth condition was later included in our analysis to shed light on the 'teachable moment' for PW especially (learner-controlled PW only, $n = 9$).

Learning material

An adapted version of the multimedia practical *Preparing a Plea* (Wöretshofer et al., 2000) had to be studied as part of the court practical participants had enrolled for. The goal of the program, with an average study load of about 40 hours, is to promote the ability to prepare and carry out a plea in court. Figures 2.1, on page 19, and 4.1, on page 57, show some of the main screens of the multimedia practical.

The multimedia practical starts with the participants' familiarization with the program and the stepwise procedure. Then, the participants receive a nine-step whole-task training, consisting of one compulsory *training task* (the civil law case 'Bosmans'), together with another training task (the criminal law case 'Ter Zijde') and two additional cases for extra practice. Participants are required to hold the training plea about 'Bosmans', but can either choose to hold their *transfer plea* about the second non-compulsory training task (i.e. criminal law case) or about one of the two practice tasks (i.e. one commercial and one administrative law case). Performance on the second plea, which was held about one month after the initial training, was taken as a measure of transfer.

Within every step of the whole-task training students have maximal freedom of study; the nine steps of the SAP have been described in Chapter 2 (on pages 18-19). Since our previous study showed that students might need more opportunity to practice the SAP, during this experiment the criminal law case 'Ter Zijde' could also be prepared according to this nine-step procedure with every step containing comparable cueing. Extra cases are included to create a higher variability of practice.

Participants received a general prior knowledge questionnaire (Nadolski, Kirschner, & Van Merriënboer, 2004) with about fifty items pertaining to commitment to the field of Law (like reading law journals, looking at law programs), prior presentation skills (prior writing and oral presentation skills, membership of a debating club), and computer skills (computer literacy, attitude towards learning with computers), age and gender.

Pleading measurement instruments

Specific pleading measurement instruments (see Chapter 3) were used to determine the quality of the pleading inventory (PI, outcome of step 3), the pleading note (PN, outcome of step 6), and the plea (PB, outcome of step 9), each for training task 'Bosmans'. An average of sixty, pre-defined and weighed, detailed items was scored for each of these instruments; these items pertain both to correctness of selected legal content (e.g., Does the pleading inventory contain a specific legal question?) and adequateness of presentation (e.g. Does the introduction to the pleading note not exceed 10 percent of the total text?). The performance scores on the PI, PN, and PB instruments were taken as measures of learning outcome on the training task. The transfer pleas (P2, outcome of step 9) were scored with the 'plea checker' tool that is contained in the multimedia practical; this tool consists of nine, pre-defined items, that pertain to getting attention (introduction), consistency, legal correctness, captivity and clarity of the plea (main body of text), and to 'anchoring' the main points and giving initiative back to the judge (closing remarks). All scores were normalized on 100-point scales. Inter-rater reliability and consistency of all scores were assessed using intra class correlation (ICC) and Cronbach's alpha. The ICC (3, k) two-way mixed model (Shrout & Fleiss, 1979) for the PI, PN, PB, and P2 instruments revealed significant average measures of reliability (AMR) on absolute agreement of .89, .77, .86, and .93 respectively, with ICC > .70 generally considered to be acceptable (Yaffee, 1998). Cronbach's alpha's for internal consistency of these instruments were .97, .94, .86, and .93 respectively. The use of the plea checker for scoring plea performance appeared reliable, which was confirmed by a high Cohen's kappa (Kappa = .67, $p < .001$), although variance of all transfer plea results appeared to be too narrow ($M = 72.94$, $SD = 9.22$, Variance = 8.50) for sufficient differentiation between conditions.

The participants were asked to rate the perceived amount of mental effort invested in each step of the training task on an adapted version of the 9-point scale developed by Paas (1992). Extra time-on-task spent outside the program for each step, together with relevant scores on the questionnaire, was taken to assess motivation (on a 12-point scale). As all conditions were computer-delivered, the participants' actions (e.g., when using cueing) and study times were logged.

Design and Procedure

Three versions of the computer program were produced that only differed on the cueing provided for both training tasks (cases 'Bosmans' and 'Ter Zijde'). In the learner-controlled cueing condition participants could look into available PW and WOE for all steps and cases at any time (see Figure 4.1); the filled-in PW could however only be send in for assessment within the appropriate step. In the system-controlled cueing condition participants received a PW with instruction at the start of each step, and an expert WOE after submitting their own report at the end of each step. In the no-cueing condition participants received rather global step instructions without further cueing. All versions presented identical support tools, like a 'plea checker' to analyze pleas, discussions of ethical issues in pleading, numerous files and documents, and the two non-compulsory practice dossiers.

Before the start of the experiment the participants were informed, both by a recruitment text and later by a written instruction and manual with the program, about the study load and the required prior knowledge and computer skills. Participants were then randomly assigned to one of the experimental conditions. All learning materials (including the written instructions and manuals) were sent to the participants' home addresses. Together with the program participants received the questionnaire, which they had to fill in and return before starting to work on the program. The experimental program had to be completed within three months. After about eight weeks (having spent approximately 25 study hours on the multimedia practical), participants were required to hold the plea for the training task (case 'Bosmans'). This plea was recorded on videotape. About four weeks later (approximately an extra 15 study hours), participants were required to hold the transfer plea about a case of their choice. Two court practical teachers used the 'plea checker' tool to assess closing pleas live but independently.

Participants were advised to work step-by-step on the reports they had to send in electronically for rating and logging after the training plea. They were urged and controlled to work individually and not to discuss anything with fellow students or teachers in order to maintain independence. The experimenters extracted the pleading inventories and pleading notes, copied the videotaped training pleas, and forwarded these to the raters (graduated Law students). The reports and videotaped pleas were blindly and independently scored.

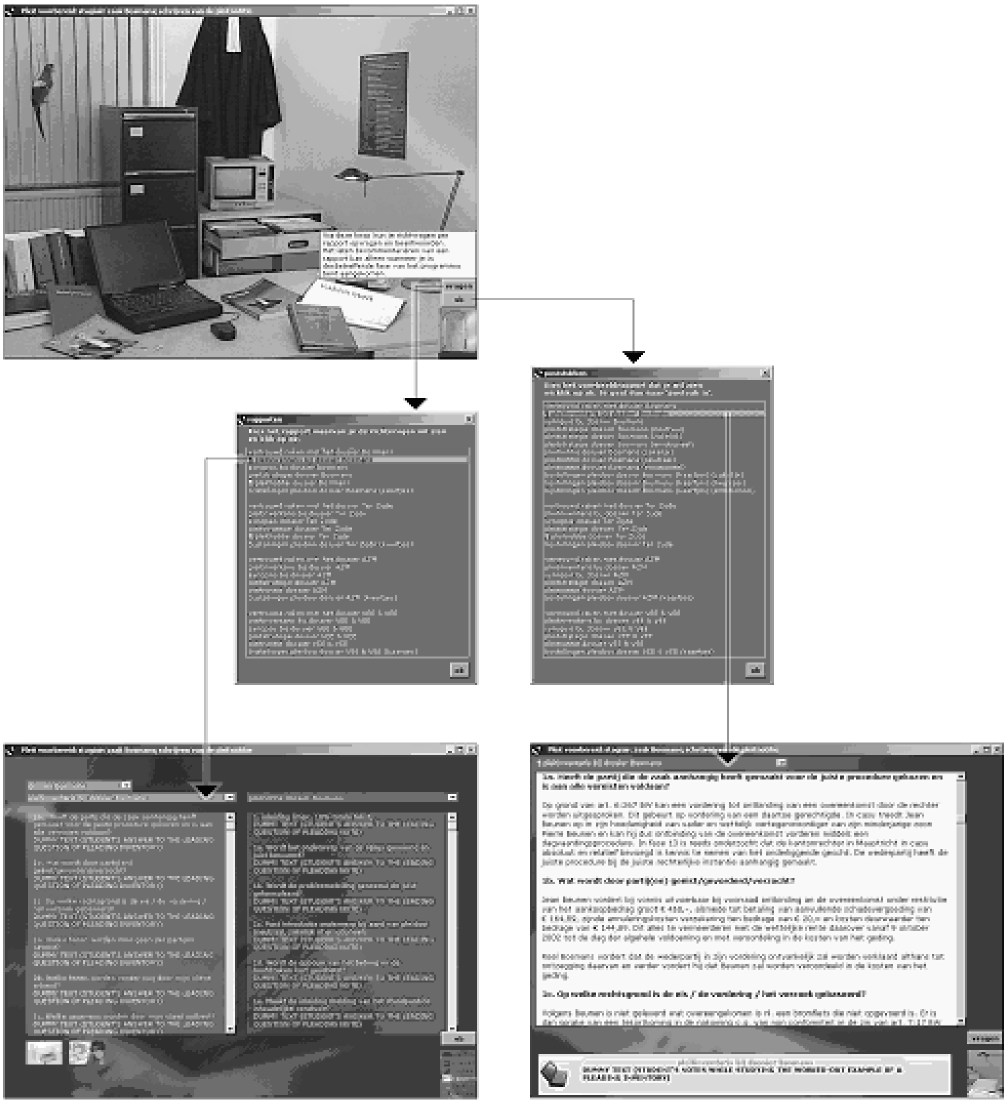

Figure 4.1: Screendumps from Preparing a plea: Learner-controlled cueing
Participants studying Preparing a plea are given the role of trainee or junior lawyer in a (virtual) legal firm. The participants in the learner-controlled cueing condition can ask for PW and WOE whenever they feel is the appropriate moment. The above screendumps show some actual screens for a participant in the learner-controlled cueing condition. At every time and place (in the case of the upper screen: in trainee's office) two buttons are available for PW ('vragen') and WOE ('vb'). Via listboxes (in a popup menu) learners select PW (on the left side) or WOE (on the right side) of their choice. PW can be worked on during every step, but can only be send in to the (virtual) mentor for assessment when learners have actually proceeded to that step.

To examine effects of learner control on PW, some additional data were collected or were already available from two extra groups of participants. These participants followed the exact same design and procedure and could be compared on the exact same learning outcomes: one extra (fourth) condition receiving only PW (and no WOE) on learner demand (from the same population of this experiment, $n = 9$); and one extra (fifth) condition receiving only PW (and no WOE) at fixed moments (from the population of the experiment described in Chapter 3, $n = 12$).

Results

Data were analyzed with one-way analyses of variance (ANOVA) to examine the expected main effect of cueing condition (either 'learner-controlled cueing', 'system-controlled cueing' or 'no cueing') as the between-subject factor on various dependent variables: learning outcomes (pleading inventory, pleading note, training plea), transfer plea outcome, and time-on-task, mental effort and motivation measures. Following significant omnibus F-tests on these variables, two planned contrasts using Bonferroni's correction were carried out to confirm expected group differences both between groups that did and did not receive cueing, and between the learner- and system-controlled cueing groups; all reported significances are one-tailed. Pearson's r correlations were used to examine possible relations between dependent variables.

Learning outcomes

Logging data show that all participants sent in required reports for pleading inventory and pleading note and did not skip steps. The learning outcomes as a function of cueing condition are summarized in Table 4.1.

Table 4.1: *Performance scores (normalised to 100 point-scales) on the pleading inventory, pleading note, training plea, and transfer plea*

	Learner-controlled cueing ($n = 12$)		System-controlled cueing ($n = 12$)		no cueing ($n = 10$)		All ($N = 34$)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Pleading inventory	44.83	21.25	29.42	10.27	19.20	8.43	31.85	17.80
Pleading note	67.67	18.16	48.58	27.39	53.20	16.62	56.68	22.49
Training plea	77.00	9.26	70.83	7.22	61.00	11.86	70.12	11.27
Transfer plea	77.08	9.16	70.42	8.38	71.00	9.37	72.79	9.22

Analysis of variance on the learning outcomes reveals main effects of cueing condition on the pleading inventory (F (2, 31) = 8.46, MSE = 218.26, p < .01, η_p^2= .35) and the training plea (F (2, 31) = 7.83, MSE = 89.80, p < .01, η_p^2= .34), but only approaching significance on the pleading note (F (2, 31) = 2.55, MSE = 462.42, p = .09, η_p^2 = .14). Contrasting both cueing conditions with the 'no cueing' condition reveals a significant difference (t (31) = 3.22, p < .01) on pleading inventory in favor of cueing. Furthermore, contrasting the learner- and system-controlled cueing conditions reveals a significant difference (t (31) = 2. 56, p < .05) on pleading inventory in favor of learner control. Contrasting both cueing conditions with the 'no cueing' condition reveals a significant difference (t (31) = 3.62, p < .01) on training plea in favor of cueing. Furthermore, contrasting the learner- and system-controlled cueing conditions reveals a difference (t (31) = 1.60, p = .06) on training plea, although only approaching significance, in favor of learner control. An independent samples t-test comparing training plea outcomes between learner- and system-controlled cueing groups did reveal a significant difference (t (22) = 1.82, p < .05) on training plea outcomes.

Table 4.2: Significant independent samples t-test differences between conditions (best vs. worst condition) on various learning outcomes

	1 vs. 2	1 vs. 3	2 vs. 3	1 vs. 4	4 vs. 3	2 vs. 4
	t (22)	t (20)	t (20)	t (19)	t (17)	t (19)
Pleading inventory	2.26 *	3.58 **	2.52 *	2.22 *	2.18 *	-
Pleading note	2.01 *	1.93 *	-	2.18 *	-	-
Training plea	1.82 *	3.55 **	2.39 *	2.32 *	1.73 ◊	-
Transfer plea	1.86 *	1.53 ◊	-	-	-	-

* p < .05 (one-tailed, as predicted)

** p < .01 (one-tailed, as predicted)

◊ p < .07 (one-tailed, as predicted)

Condition 1 = learner-controlled cueing (PW+WOE); condition 2 = system-controlled cueing (PW+WOE); condition 3 = no cueing; condition 4 = learner-controlled PW only

A series of uncorrected independent samples t-tests (see Table 4.2) reveals that learner-controlled cueing is superior to both other conditions on *all* learning outcomes. Furthermore, the system-controlled cueing condition outperforms the no-cueing condition on the pleading inventory and training task.

Closer inspection reveals the added value of learner-controlled PW alone. An independent samples t-test comparing participants (n = 12) from the extra condition 5, that drew up pleading inventories (M = 22.50, SD = 7.59) and held pleas (M = 60.17, SD = 5.58) for the training task 'Bosmans' with PW at the start of each step (from the experiment described in chapter 3), with participants from the extra condition 4 (n = 9), that were provided PW on demand to draw up pleading inventories (M = 28.00, SD = 9.15) and hold pleas (M = 68.67, SD = 6.31) during the very same training task, revealed the beneficial effect of timing on both pleading inventory (t (19) = 1.51, p =.07, one-tailed), although only approaching significance, and pleading performance (t (19) = 3.27, p < .01, one-tailed), as we expected.

Transfer

Analysis of variance on the transfer outcomes reveals no main effect of cueing condition on the transfer plea (F (2, 31) = 2.00, MSE = 80.19, p = .15, η_p^2 = .11). The choice of transfer plea did not influence final performance (F (2, 31) = .25, MSE = 89.07, p = .78, η_p^2 = .02).

Time-on-task, mental effort and motivation

Differential effects of cueing condition on motivation, mental effort and time-on-task scores were analyzed to control for possible confounding effects on learning outcomes. Analysis of variance of the motivation scores for the learner-controlled (M = 2,25, SD = 1.14), system-controlled (M = 2.17, SD = 1.03) and no cueing condition (M = 1.80, SD = 1.69) reveals no differences as a function of cueing condition (F (2, 31) = .37, MSE = 1.66, p = .70, η_p^2 = .02). Likewise, average mental effort scores for these conditions (of M = 4.75, SD = .62; M = 5.17, SD = .84; and M = 5.30, SD = .68 respectively) do not differ as a function of cueing condition (F (2, 31) = 1.81, MSE = .52, p = .18, η_p^2= .10). Also, logged average time-on-task on the training task (of M = 687.75, SD = 446.62; M = 665.50, SD = 268.35; and M = 545.60, SD = 147.95 respectively) do not differ as a function of cueing condition (F (2, 32) = .61, MSE = 102,686.76, p =.55, η_p^2 = .04).

Significant Pearson's r correlations were found between time-on-task and mental effort scores (r = .41, p < .05), between pleading inventory results and results for both the training (r = .42, p < .05) and transfer plea (r = .38, p < .05), but not with pleading note. A relation was found between pleading note results and results for training plea (r = .37, p < .05), but not with transfer plea. Training and transfer plea results are related (r = .46, p < .01). Relations between learning outcomes also indicate that consecutive steps build on each other.

'Teachable moment' for process worksheets

A closer examination of the logging data, that were extracted from participants' working files, reveals information about the following four moments of interest: the first moment (PI_look) to examine the PW for drawing up the PI (a process-oriented step); the moment to start filling (PI_fill) in this PW for the PI; the first moment (PN_look) to examine the PW for drawing up the PN (a product-oriented step); and the moment to start filling (PN_fill) in this PW for the PN.

Table 4.3: *Moments (as percentages of time-on-task on pleading inventory or pleading note steps) participants choose to start look at PW for PI, fill in PW for PI, look at PW for PN, fill in PW for PN*

	learner control (n = 21)		system control (n = 22)		All (N = 43)	
	M	*SD*	*M*	*SD*	*M*	*SD*
PI_look	25.62	27.67	5.77	10.42	15.47	22.80
PI_fill	34.14	29.04	8.00	12.89	20.77	25.68
PN_look	14.90	19.65	6.64	18.86	10.67	19.48
PN_fill	22.76	25.92	7.09	19.16	14.74	23.80

Table 4.3 summarizes the group means for two system-controlled conditions providing PW (n = 22; the second and third condition, with participants in the 'no cueing' condition receiving an empty PW to be filled in), and two learner-controlled conditions (n = 21; first and fourth condition, that was added later). All means are expressed as percentages of the total time-on-task on the task. As expected, participants in demand of PW pick their own moment during time-on-task, while participants that receive PW upon step instruction almost immediately start looking into them (look) and filling them in (fill). Differences appear to be largest for the process-oriented training step (PI) as we expected, and lowest for the product-oriented training step (PN). 'Picking their own moment' on average means that students postpone the moment to look into PW until about a quart of the time-on-task. Most participants examined and filled in the PW during the according step. A minority (6 out of 21) of the participants even used the possibility to already start examining or filling in the PW before this step, although reports could only be send in for assessment during the accompanying step. A comparison of group differences between participants that were and were not in demand reveals significant differences for PI_look (t (41) = 3.14, p < .01, two-tailed), PI_fill (t (41) = 3.85, p < .001, two-tailed), and PN_fill (t (41) = 2.26, p = .05, two-tailed).

Discussion

We compared cueing on learner demand, cueing at fixed moments, and no cueing in a multimedia practical to prepare and hold a plea in court. We hypothesized that participants receiving cueing would outperform those not receiving cueing, and that participants receiving learner-controlled cueing would outperform those receiving system-controlled cueing. Both hypotheses could largely be confirmed. When compared to participants that received no cueing, those receiving cueing at fixed moments delivered significantly better pleading inventories and pleas on the training task, replicating earlier results (see Chapter 3). The superiority of learner-controlled cueing over other conditions was clearly demonstrated by higher performance results on these outcomes of the training task.

Results from this study provide evidence for the added value of timed cueing as process support in more adaptive problem-based learning environments. Multimedia practicals are fertile learning environments to investigate the benefits of learner control on problem-solving performance, and the possibilities for improved and more adaptive learning. It has been suggested (e.g., Ford, Weissbein, Smith, Gully, & Salas, 1998) that taking into account individual learner's needs and preferences of timing or feedback offers a method "for engaging learners more actively during training [that] leads them to learn the deeper, structural elements of the task more effectively" (p. 219). It should be noted that the relation between learner-controlled cueing and learning may not only be mediated by the timing of feedback, but also by the perceived control over feedback (Mason & Bruning, 1999; Morrison et al., 1995). Although we were not able to consider the separate contributions of both factors to learning in the naturalistic multimedia of this study, continued research on these separate issues is considered worthwhile. Another issue relates to a possible effect of cueing condition on the amount of extra practice by the participants. For instance, one could argue that participants who received cueing and / or learner control are more inclined to look into the extra practice cases. The amount of extra practice with the practice files was low for all participants (M = 6.71, SD = 13.12, in minutes), did not influence the learning outcomes, and was not influenced by cueing condition (F (2, 31) = .93, MSE = 172.70, p = .40, η_p^2= .06).

Although we find similar trends for the transfer task, we were not able to establish significant differences between both cueing conditions and the no cueing condition on transfer plea outcomes. Here some experimental flaws became clear during analysis, and might be held partly accountable. *First* of all, although pleading performance on the transfer task could be reliably measured using the 'plea checker', the overall variance is narrow and seems to have washed away significant differences in transfer. Furthermore, more specific performance on the pleading inventory of the transfer task is not assessed, so no direct measure for transfer on this step is available. *Second*, due to organisational conditions, students were left the choice over which dossier to take as transfer task. Eleven out of thirty-four participants decided not to hold a transfer plea about the second training task in the MP ('Ter Zijde'), but about one of the practice dossiers without cueing and a stepwise procedure to prepare the plea (thus experiencing less 'variability of practice' with the cueing formats in the remainder of the program). 'Variability of practice' is considered an essential element for transfer to occur (e.g., Paas & Van Merriënboer, 1994). *Third*, the overall poor results on the pleading inventories when compared to the results on both pleading notes (required to hold the plea) and pleas indicate a rather result-oriented learning style of students that are accustomed that only the pleas will get graded. It will be harder to find beneficial effects of cueing on transfer when students do not take intermediate training task outcomes that seriously.

Cueing was either absent or present and consisted of a combination of process worksheets (PW) and Worked Out Examples (WOE). The twofold purpose of whole task training is the construction of schemata that allow learners to learn unfamiliar task aspects (schema-based behavior, supported e.g. by WOE) and the automation of schemata that allow learners to effortlessly perform familiar task aspects (rule-based behavior, supported e.g. by PW) in other situations. Just-in-time presentation of cueing aimed at schema automation can be considered especially important for procedural, more process-oriented knowledge (Kester, Kirschner & Van Merriënboer, 2001). This indicates the importance of learner control for PW and the special contributions of PW to both process-oriented steps and transfer. Van Merriënboer and Sweller (in press) recently mentioned the amount of freedom students have in using prompts for self-regulation (like driving questions in a PW) as a promising method for adaptive e-learning. Differentiating between cueing formats was left out of scope in the experimental method of this study, so we will have to further research these differential effects of both learner-controlled PW and WOE on learning and transfer performance.

Findings from this study indicate special benefits of learner-controlled PW for process-oriented steps (e.g., pleading inventory) and provide us with some preliminary data on what could be the exact 'teachable' moment for PW: (a) the positive effect of timing on pleading inventory performance; (b) the superiority of 'only learner-controlled PW' compared to 'no cueing' for pleading inventory performance; (c) the interaction effect of cueing and timing on pleading inventory performance; (d) moments when participants start examining and filling in PW differ most strikingly during time-on-task on pleading inventory; and (e) the (cross-experimental) comparison of the 'only learner-controlled PW' and 'only system-controlled PW' condition on training task plea and pleading inventory, although the latter only approaching significance.

This study again shows that experimentation on schema-based learning can be carried out in the context of complex, more ecologically valid, authentic training programs of longer duration. However, due to ethical considerations, the experimental effects might have to be reduced. Even with the lack of cueing and learner control, some basic support mechanisms in the multimedia practical still guaranteed that participants, that were regular students working for credits, could successfully study. Inclusion of a 'poor' condition with no learner support would most likely have induced stronger effects of cueing and learner demand, but this was not an ethical option with regular students working for credits. Even the learning materials in the 'no cueing' condition were of high quality and, except for cueing, consisted of identical support tools. The experimental conditions had the aim to 'make this good material even better'. Furthermore, although participants were urged and controlled to work individually at home and not to discuss anything with fellow students or teachers during the experimental period in order to maintain independence, it was impossible for us to control this.

Finally, a number of possible directions for future research emerge. *First*, future research could further examine timing of isolated cueing formats either supporting schema construction or automation in relation to adaptive learning. *Second*, Winne's (1997) review of self-regulated learning research advocates a shift away from outcome-oriented feedback towards more cognitive types of feedback that support self-regulated engagement and enhance self-calibration. What exactly goes on during students' monitoring when applying this support needs further examination. Task-valid cueing (like PW and WOE) relates cues from the task to achievements, and has been found more effective in supporting learning and problem solving. Mory (2003) emphasizes timing of these new feedback types as one of the prevailing areas of future feedback research by stating "… it [feedback] can inhibit learning if it encourages mindlessness, as when the feedback is made available before learners begin their memory search or if the instruction is too easy or redundant" (p. 752). She states that future research into this 'teachable moment' (Clariana, 2000; Lewis & Anderson, 1985) should be carried out in more practical learning environments in 'real world' learning environments, with newer technologies for instructional delivery of feedback making this issue even more promising. *Third*, future research should try to find out if the results of this study could be generalised to other constructivistic learning environments within a wider variety of learning domains. These domains should include (e.g., more algorithmic) problem solving ontologies that differ from the ones in Law or related domains (e.g., those primarily driven by heuristic rules of thumb). This study shows that the examination of the effects of timing and task-valid cueing can be carried out reliably in authentic training programs of longer duration, yielding promising results about learner control.

CHAPTER 5 – **Cueing and collaboration***

Abstract

This chapter describes a study of the effects of cueing and collaboration on learning outcomes and transfer pleas, and on cognitive activity during collaboration, by combining a multimedia practical with cueing and small-group collaboration with peer feedback to support the complex task of learning to prepare a plea in court. Results reveal that both cueing and collaboration positively influence learning outcomes, and that participants without cueing benefit most from additional collaboration. Transfer plea scores reveal a positive effect of collaboration but a negative effect of cueing. Analysis of discussions during small-group collaboration revealed a negative effect of cueing on the level of cognitive activity. Negative effects of cueing are explained from a 'ceiling effect' of collaboration in combination with cueing.

Group discussion and cueing to support training complex skills

Distance education and life long learning call for individualized learning support to large and heterogeneous groups of students, especially in training complex tasks. Direct teacher-student interaction is not considered an economically feasible option in up-scaled learning environments. As a consequence, automated support via intelligent instructional techniques has long been regarded as the only viable solution. But also more regular forms of education are forced to economize on the intensity of tutoring. For instance, a considerable amount of energy and finance has gone in developing multimedia practicals to overcome this so called 'teacher bandwidth problem' (e.g., Wiley & Edwards, 2003). Preliminary studies with such practicals revealed encouraging results, for instance about the contribution of cueing to the training and transfer of complex problem-solving tasks (Hummel, Paas, & Koper, 2004a; in press). Hummel and Nadolski (2002) defined *cueing* as a type of cognitive feedback, as an instructional technique that facilitates cognitive processes to enable problem-solving transfer, i.e. the interpretation and construction of problem schemas. They studied how and when individual cueing should be provided to learners by focusing on two formats of task-valid cognitive feedback:

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* Based on: Hummel, H. G. K., Paas, F., & Koper, E. J. R. (2004). Cueing Supported Collaborative Learning: Effects of Cognitive Feedback on Individual and Collaborative Problem Solving. Manuscript submitted for publication.
The data of this chapter were presented during the 3rd Annual Hawaii International Conference on Education in Honululu, Hawaii (January 4-7, 2005).

worked-out examples (see e.g., Renkl, 2002) and process worksheets with driving questions (see e.g., Land, 2000).

Although multimedia practicals with cueing have proven to offer powerful learning environments, they may suffer from a number of weaknesses. Particularly, the laborious and costly support of individual students by teachers or automated systems may represent a problem to educational institutes. Although we expect cueing to be effective, it may at the same time be necessary to look for alternative and more efficient ways to provide support for training complex skills. Among others, Wiley and Edwards (2003) identified *collaboration* between learners providing peer feedback, the option of 'students-support-each other', as a promising solution to this problem. We will now discuss the relations between collaboration and peer feedback, structure, and cognitive activity during small-group discussion.

Collaboration and peer feedback

The potential of teamwork or other types of face-to-face collaboration for learning has been demonstrated by various studies in a variety of domains (see e.g., Barlow, Phelan, Harasym, & Myrick, 2004; Pawar & Sharifi, 1997; Pearce & Ravlin, 1987), and for Computer-Supported Collaborative Learning (CSCL) environments (e.g., Gunawardena, Carabajal, & Lowe, 2001; Gunawardena, Lowe, & Anderson, 1997). The interaction in CSCL between learners can lead to further elaboration and refinement of individually constructed schemas, since it incites learners to explicate the actual level of schema development and demands them to explicitly compare their own schemas with schemas of others as to defend or criticize (Jeong & Chi, 2000). Wiley and Edwards (2003) investigated the potential of online self-organizing social systems (OSOSS) without any central guiding authority where users provide each other with peer feedback (or 'real-time peer review') to accomplish any significant purpose. For collaborative problem solving (CPS) they found that "… learning among users *is* happening in a very innovative way" (p. 4). According to Nelson (1999) the attributes of the ideal CPS learning environment are simply: "… one conducive to collaboration, experimentation, and inquiry, an environment which encourages an open exchange of ideas and information" (p. 247). Wiley and Edwards focus their research on web-based CSCL infrastructures serving large numbers of participants, that are considered as a 'fertile primordial soup' from which OSOSS can just 'simply' emerge without centrally adding any content, commentary, structure or user support in advance. This study departs from a multimedia practical to explore if learning can be further supported by unstructured, face-to-face, small-group discussions.

Collaboration and structure

Amongst other researchers. Mevarech and Kramarski (2003) have also stated that for effective problem solving to occur there "… seems to be a need to structure the learning in small group interaction in advance in a way that will prompt students to elaborate the problem, reflect on the solution process, and really construct relationships between prior and new knowledge" (p. 450). However, by which means and to which extent collaboration should be structured in advance, whether this should be face-to-face or computer-supported, how individual and group support could be balanced, and what 'collaborative tools' could be applied in collaboration remain largely unresolved issues.

The collaboration process has been structured by presenting roles to students (Strijbos & Martens, 2001), by setting clear boundaries in terms of time and number of contributions (Owen, 2000), by providing a tool to support the explicit formulation, representation and testing of hypotheses (Van Bruggen, Kirschner, & Jochems, 2002), and by providing a negotiation tool to support the process of finding common ground in problem-solving groups (Beers, Boshuizen, & Kirschner, 2003). De Wever, Valcke and Van Winckel (2003) found that adding structure to the discussions led to higher levels of knowledge construction as measured by the levels of analysis by Gunawardena, Lowe and Anderson (1997). Providing cueing to students in advance might also indirectly structure and influence collaboration. For a first indication in this direction, Mevarech and Kramarski (2003) compared worked-out examples and meta-cognitive questions (MCQ) as instructional techniques to support mathematical problem solving and knowledge construction both during individual study and during small, face-to-face group discussions. They found the complexity of the task and the instructional technique to be important variables in mathematical communication and achievement. During face-to-face, small-group discussions about a complex mathematical task, students that had individually received MCQ demonstrated more meta-cognitive questioning and higher-levelled discourse; for a simple task WOE yielded better group discussion. This study departs from a multimedia practical to explore if cueing indirectly structures and influences small-group discussions.

Collaboration and cognitive activity

It has become apparent that characteristics of the task environment influence collaborative knowledge construction activities (e.g., Henri, 1992; 1994), and some researchers have mentioned structure of collaboration as the key variable to invoke more focused and *higher-level cognitive activity*. In order to measure increase of the level of cognitive activity by cueing, e.g., because driving questions can structure problem solving during small-group discussion, we must find ways to analyze cognitive activity. Concurrent protocols predominantly contain information on actions and concrete products (e.g., Carletta et al., 1997), and to a lesser degree information on discussions about strategies and tactics, on rules and principles that govern the problem-solving process, and on the monitoring or reflection on the task execution itself. Henri (1992, 1994) distinguished implicit interactions ('independent interventions' or 'comments to', pertaining to information that learners put in independent from others, reflecting low levels of schema elaboration), and explicit interactions ('interactive interventions' or 'answers to', pertaining to input from learners that entails the actual comparison of schemas, reflecting high levels of schema elaboration).

Our *hypotheses* for this study are that: (1) cueing will increase training and transfer task outcomes; (2) collaboration will further increase training and transfer task outcomes; and (3) cueing will indirectly structure and increase the level of cognitive activity during collaboration.

Method

Participants

Fifty junior Law students at a Dutch university volunteered to participate in the experiment, which was organized in the context of the regular court practical they had enrolled for. Students received the equivalent of about 250 US$ for participating. Participants were assigned to three conditions in a randomized controlled trial. During the experiment four participants dropped out due to study planning problems. A full dataset could be obtained from 46 participants (33 female, 13 male; mean age = 21.80, SD = 1.78). Comparability of pleading experience was assured by a prior knowledge questionnaire. The overall prior presentation skills were low (M = 3.80, SD = 3.19, on a 18-point scale) and did not differ as a function of experimental condition (F (2, 43) = 0.39, MSE = 10.49, p = .68, η_p^2 = .02).

Learning materials

Two versions of the multimedia practical *Preparing a plea* (Wöretshofer et al., 2000) were produced with cueing for both training tasks (cases 'Bosmans' and 'Ter Zijde') being either present or absent. In the 'no-cueing' groups (conditions 1 and 2) participants received global step instruction without further cueing. In the 'cueing' group (condition 3) participants could access available PW and WOE for all steps and cases at any time; the filled-in PW (reports) could however only be sent in for feedback within the appropriate step. Besides cueing, both versions presented identical support tools, like a 'plea checker' to analyze pleas, discussions of ethical issues in pleading, numerous files and documents, and two non-compulsory practice dossiers. The program has an average study load of about 40 hours, and had to be studied as part of the court practical of about 150 hours. Figure 2.1, on page 19, and Figure 4.1, on page 57, already showed some of the main screens.

This practical starts with familiarizing its operation and the stepwise procedure. Then students receive two compulsory *training tasks* (the civil law case 'Bosmans' and the criminal law case 'Ter Zijde') and two additional cases for extra practice. Within every step of these training tasks students have maximal freedom of study. During nine steps the following constituent skills for holding a plea are trained and combined: (1) ordering the file of the case; (2) getting acquainted with the file; (3) studying the file; (4) analyzing the pleading situation; (5) determining the strategy for the pleading note and plea making; (6) writing a pleading note; (7) transforming the pleading note into a plea; (8) practicing the plea; and (9) actually carrying out the plea. At the end of each of the four steps (3) to (6) students are required to send in a report to their (virtual) coach. After her approval they are allowed to proceed to the next step. The last steps are carried out outside the program. For two consecutive steps, the latter always includes cognitive feedback on the former as well as a new task instruction. Each consecutive report thus builds on the previous one. The steps under study were the construction of a pleading inventory (outcome of step 3), which is a (more) process-oriented step aimed at the selection of juridical arguments for the oral plea, and the construction of a pleading note (outcome of step 6), which is a (more) product-oriented step aimed at finalizing the written pleading note that (according to Dutch Law) has to be handed over to the judge before the lawyer is allowed to hold the oral plea in court, both within the 'Bosmans' task.

Experimental procedure

At the start of the experiment, participants were informed by a recruitment text, a written instruction and program manual about the study load of the program, required prior knowledge and computer skills, possible meeting dates, and overall planning. They were randomly assigned to one of three conditions and one meeting, and invitations for meetings were sent at least three weeks in advance. Learning materials (including the instruction, manual and prior knowledge questionnaire) were sent to the participants' home addresses. The questionnaire had to be filled in and returned before starting to work on the program.

Five weeks were allowed for study of the practical to the point participants had to send in their individual pleading inventory (step 3 for 'Bosmans' case), and another two weeks to send in their individual pleading note (step 6 for 'Bosmans' case), averaging a total of about 25 study hours. Participants were urged and controlled to work individually on the program and not to discuss anything with fellow students or teachers in order to maintain independence. After the individual report had been received, participants were allowed to attend the meeting and collaborate on this report in a triad of peers. All participants sent in required reports for pleading inventory and pleading note and attended the meeting; consequently, there were six triads to discuss the pleading inventory and six triads to discuss the pleading note (see Figure 5.1).

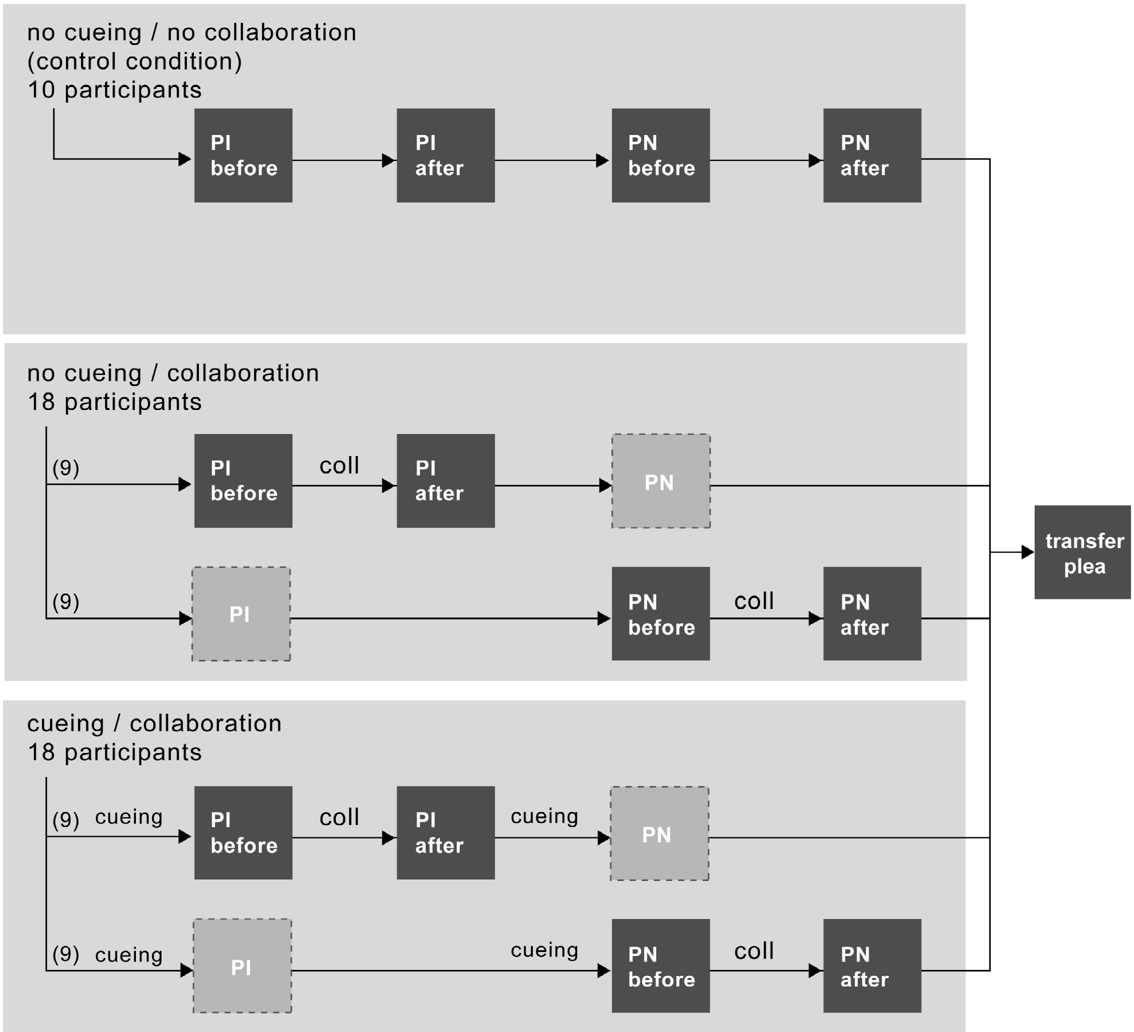

Figure 5.1: Outline of experimental procedure

PI = pleading inventory

PN = pleading note

coll = collaboration during small-group discussion

Besides the practical, students were assigned to study one of six cases on paper and prepare a plea according to the stepwise procedure at the end of the court practical.

While other court practicals that use the program demand their students to carry out a plea about a case provided by the program, this was not the case here. About another two months after the experimental period (meetings about the pleading note), the court practical ended with students holding their transfer pleas in a real courthouse.
Performance on the pleading inventory and pleading note reports were measured as intermediate learning outcomes of training; performance on the transfer plea (on another case) was taken as a measure of transfer. All reports and videotaped discussions were blindly and independently scored by two raters, who were almost graduated Law students that received a short training on the pleading measurement instruments and coding scheme.

Procedure for collaboration

At the start of each meeting, each triad of peers was read the standardized instruction by one of the experimenters, explaining purpose, set-up and 'rules' for collaboration. Group members were given each other's individual reports in print to read and compare. These reports were also electronically available on the computer for writing the group report. Their version of the program ran on another computer, slightly modified to enable access to information from previous steps. The general assignment was to reach unanimous agreement and write a group report within the time allowed. We advised them to first compare individual reports and to start writing the group report at least a quarter of an hour before deadline, but furthermore no extra directives were given and no structure was offered. From instruction to deadline, group members were allowed one-and-a-half hour for reading, discussion and writing. This period of time was videotaped for each group. Fifteen minutes after starting and fifteen minutes before ending, peers were informed about the remaining time. Before leaving, participants individually filled in the recall questionnaire and the meeting was informally evaluated.

Participants receiving 'cueing / collaboration' received an e-mail containing expert's worked-out example directly after the meeting (which concluded the step). Participants receiving 'no cueing / no collaboration' had to be controlled for confounding time-on-task effects. They received individual reports from other peers by e-mail, with the request to (individually) adjust their report. To control for time-on-task effects, they were instructed to spend the same amount of time as was granted during meetings, and again send in their adjusted pleading inventory and pleading note.

Questionnaires and pleading measurement instruments

The prior knowledge questionnaire (Nadolski, Kirschner, & Van Merriënboer, 2004) pertained to commitment to the field of Law (reading legal journals, watching legal programs), prior presentation skills (both writing and speaking in public, membership of debating club), and computer skills (familiarity with and attitude towards computers). The recall questionnaire pertained to the way participants experienced the meeting, and (only for condition 3) the role cueing had played during individual and group work on the report. The items of this recall questionnaire are listed in Table 5.1.

Table 5.1: Recall questions after collaboration with means and standard deviations (n = 36 for items 1 to 5; n = 18 for items 6.1 to 7.3e)

Nr	Question	Scale / options	*M*	*SD*
1	How much mental effort did you feel during the group discussion?	Very, very little (1) – Very, very much (9)	3.53	1.44
2	How motivated were you during the group discussion?	Very, very little (1) – Very, very much (9)	6.25	.97
3a	Indicate which statements are true, by dividing 10 points over …. [a-e]	Discussion took place in a positive atmosphere	2.39	.78
3b	……	Discussion led to new knowledge and improvement of the report	1.89	.83
3c	……	I made a substantial contribution to the group report	2.22	.44
3d	……	I was able to clarify my opinions	1.89	.60
3e	……	There was considerable mutual misunderstanding and conflict	1.44	1.24
4	Indicate to which extent the discussion led to new knowledge and improvement of the report	Very little (1) – Very much (5)	3.42	.77
5	Which improvements will make the meeting more efficient?	Open question	-	-
6.1	Did you make use of the worked-out examples (WOE) when writing your individual report?	Very little (1) – Very much (5)	3.22	1.66
6.2	Did you make use of the worked-out examples (WOE) when writing the group report?	Very little (1) – Very much (5)	2.83	1.15

6.3a	Indicate the contribution of WOE on the group discussion, by dividing 10 points over …. [a-e]	Used while orienting on the task	1.61	1.92
6.3b	…….	Used while planning the task	1.17	1.30
6.3c	…….	Used while executing (process) the task	2.00	1.82
6.3d	…….	Used while finalizing (product) the task	2.94	2.51
6.3e	…….	Did not use them	2.28	2.89
7.1	Did you make use of thedriving questions (PW) when writing your individual report?	Very little (1) – Very much (5)	3.00	1.57
7.2	Did you make use of thedriving questions (PW) when writing the group report?	Very little (1) – Very much (5)	1.94	1.40
7.3a	Indicate the contribution of PW on the group discussion, by dividing 10 points over ….[a-e]	Used while orienting on the task	.94	1.35
7.3b	……	Used while planning the task	1.11	1.45
7.3c	……	Used while executing (process) the task	3.67	2.50
7.3d	……	Used while finalizing (product) the task	.72	1.02
7.3e	……	Did not use them	3.56	3.18

Specific pleading measurement instruments (see also Nadolski, Kirschner, & Van Merriënboer, 2004; Hummel, Paas, & Koper, 2004a; in press) were used to determine the quality of the pleading inventory (PI), pleading note (PN) and transfer plea. One teacher scored the transfer pleas using the 'plea checker' tool from the program, which consists of nine criteria (like drawing attention, anchoring the message, consistency and legal correctness). The first two instruments were independently scored by two almost graduated Law students on an average of sixty items that pertain to both correctness of legal content and adequateness of presentation. Scores were normalized on 100-point scales. Inter-rater reliability and consistency were assessed using intra class correlations (ICC) and Cronbach's alphas. The ICC (3, k) two-way mixed model (Shrout & Fleiss, 1979) for the PI and PN instruments revealed significant average measures of reliability (AMR) on absolute agreement of .89 and .78 respectively, with ICC > .70 generally considered to be acceptable (Yaffee, 1998).

Cronbach's alphas for internal consistency of these instruments were .91 and .80. The plea checker appeared reliable in an earlier study by Hummel, Paas and Koper (in press).

Participants were asked to score the perceived amount of mental effort, both during individual study and collaboration on the step, on an adapted version of the 9-point scale developed by Paas (1992; see also Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Extra time-on-task spent *outside* the program while constructing the individual report for the step ($M = 60.54$, $SD = 47.58$, in minutes), together with relevant scores on the prior knowledge questionnaire, was taken to assess motivation (on a 12-point scale).

Coding scheme

Complex problem-solving processes are typically hard to observe because they take place 'in the solvers head', and quite frequently, the only external evidence is the final solution reported. The coding scheme for analyzing cognitive activity during group work had to meet certain requirements (see e.g., Veldhuis-Diermanse, 2002). First of all, categories had to be based on our theoretical orientation (schema-based learning) and research questions, and therefore represent relevant types of cognitive activity. Second, categories should be based on the steps and content domain (i.e. the domain of civil Law) that guide this study. They should reflect the message content and contain prototype examples from these steps for each category of the coding grid. Last but not least, categories must be semantically meaningful, mutually exclusive, all encompassing and scored reliably.

Taylor and Dionne (2000) stressed that content analysis should also access the strategies used in the problem-solving process, as well as the principles and conditions under which a strategy is useful. Recently, Van Gog, Paas, Van Merriënboer and Witte (2004b), studying trouble shooting tasks with malfunctioning electrical circuits, constructed a coding scheme based on four main *types* of cognitive activity: 'action', 'how', 'why', and 'meta', which are inspired by this new approach. Apart from actions, they distinguish strategic discussions that result in actions ('how' information), principled discussions behind the strategies ('why' information), and monitoring of the problem-solving process ('meta' information).

We adopted these four main categories and extended each with a process-oriented and product-oriented subcategory, and provided domain-specific prototype examples for the eight subcategories to fit our research objective. Cognitive activity is characterized as more process-oriented when aimed at orientation, investigating, clarifying *possible* solutions to the problem, i.e. what information could be used in our report or which arguments are valid for this case. Cognitive activity is characterized as more product-oriented when aimed at finalizing or refining *chosen* solutions, i.e. how are we going to use this argument in our report or which steps are yet to be taken to draw up the report. Besides these task-valid subcategories we added four task-irrelevant subcategories. The coding scheme is presented in Table 5.2.

Table 5.2: Coding scheme for cognitive activity during collaboration

Nr	Main Category	Sub Category	Activity related to …	Prototype examples Bosmans case
1	PRODUCT	ACTION	*Executing actions*: apply information, writing, dictating, editing, ….	- How are we going to phrase this argument? - We should place to most important argument first in the list. - Let's delete that sentence anyway.
2	PROCESS	ACTION	*Preparatory actions*: search information, reading aloud, selecting usable information, ….	- Reading aloud the exact text of the demanding party (what exactly is claimed here). - What is mentioned about this type of Honda? - What was the story behind the insurance?
3	PRODUCT	HOW	Discussing the *chosen* strategies or tactics, e.g. how to apply the solution or worked-out examples in the report.	- Are we claiming or disbanding the contract? - What is primary, subsidiary, ..? - Are we going to use liability? - Are we going to charge the process costs? - We better combine a neutral plea with emotions, but only when relevant.
4	PROCESS	HOW	Discuss *possible* approaches or heuristics for report, e.g. examine case law, consult experts, or apply driving questions and criteria.	- Can we use article 717 sub 4 as an exemption to non-conformity? - Does plaintiff claim miscarriage? - Should we include the meaning of opposing party in this argumentation? - Could we urge for minority as excuse? - Should we speak about mutual miscarriage?

5	PRODUCT	WHY	Discussing juridical principles, rules and facts behind the *chosen* solution.	- Mentioning default is redundant here. - If article 218 sub c, then refer to 6:230 - Are we addressing this issue in a relational or more objective tone? - We should restrict to sub c, because …. - Which facts are still missing ?
6	PROCESS	WHY	Discussing juridical principles, rules and facts behind *possible* solutions.	- Does default apply here? - Now, what exactly is the juridical question? - Is there a principal difference between making one or two test drives? - What is technical state of the Honda ? - Does a duty of giving notice apply?
7	PRODUCT	META	Orientation, monitor and evaluate solution	- Let's leave headings bold-faced … - What should happen with this report? - Do you still think this sums it up well?
8	PROCESS	META	Orientation, monitoring and evaluating the collaboration	- Is everybody satisfied? - We should start dividing tasks. - Lets first have a look at what everybody has as extras.
9-12	TASK IRRELE-VANT	[various]	Praise / complaints about program or meeting. Read or write individually. Fragments that cannot be scored.	- How irritating that you cannot scroll through or print those documents - Replacing the computer or flap-over. - Audio fragment is not audible (bad quality of recording).

We have taken the proportion of discussion as measure for the *level* of cognitive activity by adopting the operational definition of Garafolo and Lester (1985): "Cognition is involved in doing, and meta-cognition is involved in choosing and planning what to do and monitoring what is being done." (p. 164) In accordance with their definition we define cognitive behavior as information-processing *actions*, such as reading, writing, or announcing final solutions. Only when students are really engaged in *discussions* about the problem, and their comments could be heard, do we consider behavior to indicate meta-cognitive activity.

For the actual coding we applied a method of time sampling, scoring the type of cognitive activity on every exact minute. Videotapes displayed a uniform time-code in the upper left hand corner of the screen. Inter-rater reliability of the (first time use) coding scheme was assessed (with $k = 2$) and appeared to be (very) satisfactory both on the level of the five main categories ($K = .87$, $N = 1{,}080$) and the twelve subcategories ($K = .85$, $N = 1{,}080$). Leaving out the proportion (27,5%) of task-irrelevant behavior (subcategories 9-12), these measures were even a little higher both on the level of the four main categories ($K = .89$, $N = 758$) and eight subcategories ($K = .89$, $N = 758$). In qualitative analysis, a Cohen's kappa between .81 and 1.00 is considered 'almost perfect' (Heuvelmans & Sanders, 1993, p. 450).

Experimental design

Participants in the 'cueing / collaboration' condition ($n = 18$) received individual training through a version of *Preparing a plea* with cueing, and additional collaboration on one of the steps under study. In the 'no cueing / collaboration' condition participants ($n = 18$) received a version of the program without cueing, but with the additional collaboration. In the third 'no cueing / no collaboration' (control) condition, participants ($n = 10$) received neither cueing nor collaboration.

We applied a *between-groups design*, with half ($n = 18$) of the invitees for collaboration, equally divided over experimental conditions 2 and 3, to attend a group discussion on the pleading inventory, and the other half ($n = 18$) to attend a group discussion on the pleading note about two weeks later (see Figure 5.1 for a graphical display of this procedure). Participants ($n = 36$) in these experimental conditions were randomly assigned to a triad of peers within the same condition.

Results

Repeated measures ANOVA was applied on the general outcomes, using time of measurement (before or after collaboration) as a within-subjects factor and experimental condition (either 'cueing / collaboration', 'no cueing / collaboration', or 'no cueing / no collaboration') as the between-subjects factor. Analyses of variance (ANOVA) were applied with experimental condition as between-subject factors, and with various learning outcomes (general outcomes before and after collaboration, pleading inventory and pleading note scores before and after collaboration, and transfer plea scores), scores on the items of the recall questionnaire, motivation, mental effort, and time-on-task scores as dependent variables. The partial-eta-squared statistic was used as an effect size index where values of .01, .06, and .14 correspond to small, medium, and large values, respectively (Cohen, 1988). Coding scores from small-group discussions during collaboration were analyzed with Mann-Whitney tests with the level and types of cognitive activity as dependent variables. Finally, independent t-tests were used to compare learning growth differences between experimental conditions.

Learning outcomes before and after collaboration

All learning outcomes before and after collaboration are summarized in Tables 5.3A and 5.3B. A repeated measures ANOVA revealed main effects for time of measurement (F (1, 44) = 38.36, MSE = 408.71, p < .001, η_p^2 = .47) and experimental condition (F (2, 43) = 3.31, MSE = 408.71, p < .05, η_p^2 = .13), but no interaction effect (F (2, 43) = 1.62, MSE = 23.66, p = .21, η_p^2 = .07). The intermediate learning outcomes on pleading inventory (PI) and pleading note (PN) after making adjustments (either during collaboration or individually) were significantly better than those before for *all* three conditions. To establish one general outcome before and one after adjustment for *all* participants, we used individual reports (PI before or PN before) and group reports (PI after or PN after) for participants in conditions 2 and 3 (receiving collaboration), and averaged the scores on both reports (PI and PN before, PI and PN after) for participants in condition 1 (not receiving collaboration).

Pleading inventory and pleading note scores. There was a *main effect of cueing* on both PI and PN scores *before*. One-way ANOVA show that participants who received cueing outperform those that did not on the PI (F (1, 26) = 9.80, p < .01) and PN scores (F (1, 26) = 26.66, p < .001). There was also a *main effect of collaboration* on the PI and PN scores *after*. One-way ANOVA show that participants who collaborated finally delivered better PI (F (1, 26) = 5.98, p < .05) and PN (F (1, 26) = 45.68, p < .001) than participants that had to adjust the reports individually.

Table 5.3A: Scores on pleading inventory (PI) and pleading note (PN) before and after collaboration (n = 28)

	no cueing / no collaboration (*n* = 10)		no cueing / collaboration (*n* = 9)		cueing / collaboration (*n* = 9)		All (*n* = 28)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
PI before	30.30	5.17	30.67	5.20	38.67	8.87	33.11	7.45
PI after	36.70	8.16	41.22	8.27	47.22	5.83	41.54	8.49
PN before	53.90	9.54	59.89	3.33	71.67	5.59	61.54	9.98
PN after	56.10	6.17	67.11	3.95	72.89	3.33	65.04	8.50

General outcomes. We also found a *main effect of cueing* on all general outcomes *before* (F (1, 44) = 5.86, MSE = 248.29, p < .05, η_p^2 = .12). This effect could be confirmed by a contrast test using Bonferroni correction, that revealed better results for participants in the 'cueing' condition when compared to both 'no cueing' conditions taken together (t (43) = 2.50, p < .01, one-tailed). A *main effect of collaboration* was found on the general outcomes *after* (F (1, 44) = 4.79, MSE = 184.41, p < .05, η_p^2 = .10).

An *interaction effect of cueing and collaboration* was found on the general outcomes *after* (F (2, 43) = 3.29, MSE = 181.44, $p < .05$, $\eta_p^2 = .13$), but not on the increase (growth) in learning outcome (F (2, 43) = 1.30, MSE = 44.41, $p = .28$, $\eta_p^2 = .06$). General outcomes before and after appear to differ significantly (t (45) = -6.47, $p < .001$). Finally, we noted that the relative increase in learning outcome (growth) was highest for participants receiving 'no cueing / collaboration' (condition 2). However, independent t-test comparisons of conditions 3 with 2 (t (34) = 1.43, $p = 0.08$, one-tailed) and 2 with 1 (t (26) = 1.21, $p = .11$) only approach significance. Only a minority of 5 participants (of which three in condition 3, one in condition 2, and one in condition 1) suffered negative learning growth on their pleading inventory or pleading note outcome, but decreases were small (averaging about four points on a 100-point scale).

Table 5.3B: General outcomes before and after collaboration, learning growth and transfer plea scores (N = 46)

	no cueing / no collaboration (*n* = 10)		no cueing / collaboration (*n* = 18)		cueing / collaboration (*n* = 18)		All (*N* = 46)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Outcome before	40.70	9.79	45.28	15.62	55.17	18.44	48.15	16.59
Outcome after	46.50	9.36	54.17	14.73	60.26	13.98	54.80	14.14
Growth (delta)	5.80	5.01	8.89	7.12	5.09	6.92	6.91	6.71
Transfer plea	67.20	13.82	77.39	6.96	70.33	9.34	72.41	10.35

Group discussion

Table 5.4 shows the aggregated results from the coding schemes on task-valid subcategories, expressed as percentages of the total number of task-valid and scored items. This table also presents the ratio of discussion (subcategories 3-8) and action (subcategories 1-2) as measure of cognitive level.

We did not find the expected main effect of cueing on the level of cognitive activity. Contrary to our expectation, we found that participants in the 'no cueing' condition (six triads) demonstrated the highest level of cognitive activity during group discussion (U = 5.00, $p < .05$). Two types of cognitive activity were demonstrated less by participants in the 'cueing' condition (six triads also), namely Category 1: action / product (U = 4.50, $p < .05$), and Category 3: how / product (U = 5.00, $p < .05$). There were no differences on the other six categories (all $p > .4$).

Table 5.4: Coding results from group discussions: categories and level of cognitive activity (expressed as percentages of the total number of scored and task-valid items)

	Cueing (n = 6)		no cueing (n = 6)		All (N = 12)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Category 1. Action / product #	37.75	4.58	29.42	5.79	33.58	6.61
Category 2. Action / process	18.67	8.80	18.92	8.66	18.79	8.32
Category 3. How / product #	7.41	3.01	13.67	5.69	10.54	5.43
Category 4. How / process	11.08	9.01	11.42	4.09	11.25	6.67
Category 5. Why / product	7.08	2.91	6.67	2.94	6.88	2.80
Category 6. Why / process	8.67	1.75	10.42	4.12	9.54	3.15
Category 7. Meta / product	4.42	3.50	5.58	1.85	5.00	2.74
Category 8. Meta / process	4.83	1.97	3.92	2.50	4.38	2.20
Level (of cognitive activity) #*	43.58	4.50	51.68	6.30	47.63	6.71

\# Significant difference ($p < .05$) between conditions

* Level of cognitive activity is portion of discussion (categories 3-8)

Recall questionnaire

Scores on the recall questionnaires (see Table 5.1) give insight into personal *perception* of collaboration and the effect of cueing on this perception. Results show that participants felt highly motivated ($M = 6.25$, $SD = .97$, on a nine-point scale) and little mental effort ($M = 3.53$, $SD = 1.44$, on a nine-point scale) during collaboration. Paired t-tests that compare motivation and mental effort scores during the meeting with the same scores while individually studying the steps ($M = 3.80$, $SD = 1.70$ and $M = 5.50$, $SD = .91$ respectively) reveal strong differences ($t\ (35) = 7.05$, $p < .001$ and $t\ (35) = -7.03$, $p < .001$ respectively). Participants receiving 'no cueing' ($M = 6.72$, $SD = .83$) appear most motivated during collaboration when compared to participants receiving 'cueing' ($M = 5.78$, $SD = .88$; $F\ (1, 34) = 11.04$, $MSE = .73$, $p < .01$, $\eta_p^2 = .25$).

The *perceived* amount of learning increase through collaboration ($M = 3.42$, $SD = .77$, on a six-point scale) could not be attributed to cueing ($F\ (1, 32) = 1.12$, $MSE = .62$, $p = .30$, $\eta_p^2 = .03$). Table 5.1 presents results on all items of the recall questionnaire. As expected, participants that receive cueing (n = 18) value driving questions (PW) more for discussing PI than for discussing PN ($F\ (1,16) = 9.78$, $MSE = 1.28$, $p < .01$, $\eta_p^2 = .38$; item 7.2), and value worked-out examples (WOE) more while executing the step PN than while executing the step PI ($F\ (1, 16) = 5.45$, $MSE = 2.61$, $p < .05$, $\eta_p^2 = .25$; item 6.3c).

Transfer

Analysis of variance on the transfer performance data reveals an unexpected (negative) main effect of cueing on transfer plea scores (F (1, 44) = 4.79, MSE = 93.63, p < .05, η_p^2 = .10). The expected (positive) main effect of collaboration on the transfer plea scores (F (1, 44) = 7.13, MSE = 93.63, p < .05, η_p^2 = .14) was also found.

Time-on-task, mental effort and motivation

An ANOVA of the motivation scores during individual study for participants receiving 'cueing / collaboration' (M = 3.39, SD = 1.61, n = 18), 'no cueing / collaboration' (M = 4.44, SD = 1.92, n = 18) and 'no cueing / no collaboration' (M = 3.40, SD = 1.07, n = 10), reveals no differences as a function of condition (F (2, 43) = 2.22, MSE = 2.72, p = .12, η_p^2 = .09). Average mental effort scores during individual study for these groups (M = 5.22, SD = .88; M = 5.89, SD = .90; and M = 5.30, SD = .82 respectively) do not differ as a function of condition (F (2, 43) = 2.94, MSE = .77, p = .06, η_p^2= .12). Finally, average time-on-task scores on the steps (M = 168.06, SD = 63.78; M = 204.17, SD = 85.03; and M = 183.50, SD = 38.15 respectively, all in minutes) do not differ as a function of condition (F (2, 43) = 1.24, MSE = 4,771.44, p = .30, η_p^2 = .05).

Discussion

We compared participants that did and did not receive cueing or collaboration. We hypothesized that (1) cueing would increase learning outcomes and transfer pleas, and that (2) collaboration would further increase these outcomes. In addition, it was hypothesized that (3) the level -of cognitive activity during collaboration would be indirectly influenced by cueing, in such a way that 'cued' participants would engage in higher-levelled discussion with more strategic and principled cognitive activity than 'not cued' participants.

The first two hypotheses could be partially confirmed. Results show that cueing improves pleading inventories and pleading notes, replicating earlier findings by Hummel et al. (2004a; in press), and that collaboration further improves these reports. A comparison of general outcomes reveals main effects and an interaction effect for cueing and collaboration. Transfer measures on closing pleas revealed the expected positive effect of collaboration but not for cueing. We had to reject our third hypothesis. The level of cognitive activity and the amount of strategic discussion were higher for 'not cued' participants.

The interaction effect of cueing and collaboration indicates that both work together in increasing learning outcomes. This will also explain why 'not cued' participants appear to benefit more from collaboration and also feel more motivated during collaboration. We believe this can be explained by a *'ceiling effect'* of collaboration when combined with cueing. 'Not cued' participants still are to receive a lot of new information during collaboration (through peer feedback); they still have a lot of 'choosing and planning' (Garafolo & Lester, 1985) to catch up on. 'Cued' participants have already received some of this information through PW and WOE in the program. Phrased in schema-based learning terminology, one could state that the schemas of the 'not cued' participants are still more 'under construction', needing a higher level of schema elaboration and monitoring (Henri, 1992, 1994). 'Cued' participants, who had received more strategic and principled cues before collaboration (from PW and WOE), are left with 'merely doing' (low level of schema elaboration and monitoring) and simply do not have that much to gain from each other anymore. These results give reason to believe that 'students-support-each other' is indeed a feasible option to complement or substitute cueing when training complex learning tasks.

A number of possible directions for future research emerge from this study. *First*, it would be interesting to conduct studies to compare the benefits of face-to-face collaboration (as in this study) with computer-supported collaboration (as in most concurrent CSCL/CSCW research). CSCL might be less powerful (e.g., because it lacks direct and non-verbal interaction), but can also be more feasible (less demanding to attend and more flexible to organize).

Second, we should try to extend these findings to domains that share the same type of problem-solving ontology as for Law (i.e. one based on heuristic rules and strategic approaches, rather than on strict algorithms, rules or procedures).

Third, further experimentation on schema-based learning should and can be carried out in the context of complex, ecologically valid, authentic training programs of longer duration. The current study demonstrates that it is feasible to combine experimental control (especially on cueing and collaboration) with authentic contexts of study. However, due to ethical considerations, the experimental effects might have to be reduced. Even with the lack of cueing or collaboration, some support mechanisms in the program still guaranteed that participants, that were regular students working for credits, could still successfully study. Inclusion of a 'very poor' condition without support would most likely have induced stronger effects of additional cueing and collaboration, but this was not a realistic option here. Furthermore, although participants were urged and controlled to work individually at home and not to discuss anything with fellow students or teachers during the experimental period in order to maintain independence, future research should find ways to further control this, for instance by using the 'diary method' (Bolger, Davis, & Rafaeli, 2003). This method provides the field of educational psychology with ways to collect information, complementary to that obtainable by more traditional designs, on study processes within everyday learning programs of longer duration.

Fourth, we should further examine and determine the optimal balance between individual and collaborative support in training complex problem-solving tasks. What information can best be provided by individual cueing? Which information can best be discussed collaboratively? It might, for instance, be more cost-effective to develop multimedia practicals if some cueing could be left to peer feedback, and at the same time would address the teacher bandwidth problem. What would be the optimal amount of time for both? In this study participants spend an average time of about four hours on each step during individual study (M = 168.06, SD = 63.78, in minutes; with some extra time outside the program (M = 60.54, SD = 47.58, in minutes), and were allowed one-and-a-half hour for the group discussion. Some did complain (question 5) that time for discussion was too short, and some groups did not finish their report.

Finally, What has to be the optimal amount of structure for collaborative problem-solving (CPS) meetings? This study indicates that a clear purpose might be sufficient to enable efficient collaboration in small groups, and that peers do not always need more structure or 'collaborative tools'. Although some participants did complain that no tutor was available to provide expert feedback (question 5), it was fascinating to observe from the activities and outcomes of the group discussions that CPS can indeed simply emerge without any guiding authority.

CHAPTER 6 – **General discussion**

The general research question for this thesis was: *How should support for the acquisition of problem-solving skills in competence-based multimedia practicals be designed?* The main focus was on the examination of within-step cueing in 'whole tasks' to train the acquisition of complex problem-solving skills. The theoretical framework argued that adequate formats of task-valid cognitive feedback facilitate schema-based learning and problem-solving transfer. The orientation and timing of the two cueing formats, process worksheets and worked-out examples, were experimentally studied with authentic training tasks to prepare and hold pleas in court for the domain of Law.

In this thesis a model for schema construction and guidelines for adequate cueing were proposed, pleading measurement instruments were developed, the effects of timing and orientation of cueing, and the effects of collaboration in small groups, on training tasks to prepare and hold a plea and on transfer tasks were studied. This general discussion reviews the results: the theoretical frame of reference and guidelines, findings from a pilot study, and results from three experimental studies. It presents theoretical guidelines and practical implications for the design of cueing in multimedia practicals, as well as suggestions for future lines of cueing research.

Review of the results

Chapter 2 introduced theoretical guidelines for adequate cueing and proposed a theoretical model to describe relations between cueing on the one hand, and schema interpretation, schema construction, and monitoring on the other hand. Four typical formats of cueing were distinguished, depending on their orientation (either process- or product-oriented) and content (either abstract or concrete): worked-out examples, modeling examples, templates, and process worksheets. The model and guidelines were used to argue why a combination of two formats, as available in the multimedia practical *Preparing a plea*, would suit the needs for support. *Worked-out examples* are supposed to support the inductive processing of concrete descriptions to construct schemata, while *process worksheets* support the deduction of concrete problem solving steps from general prescriptions. Preliminary results from a pilot study on students' appreciation of these formats showed that students feel that the presence of both process- and product-oriented cueing lead to more focused information searching (while preparing the plea) and better performances (pleas).

In chapter 3 the effects of examples and worksheets on training tasks to prepare and hold a plea and on two transfer tasks were experimentally compared. Noticing analogies between law cases is a prerequisite for successful transfer over various realistic problem situations. The theoretical premises are that examples will stimulate imitation processes to similar (training) tasks, and that worksheets will stimulate mindful abstraction processes to different (transfer) tasks. These premises were partly confirmed by learning outcomes on the training and transfer tasks. The positive effect of examples on the learning outcomes of the training plea indicated near transfer. The positive effect of worksheets on the first transfer plea that was held after about two weeks was not found, but we did find an effect on the *delayed* transfer plea, that was held after another two months, indicating far transfer. Results from this study further suggested that instructional techniques to stimulate schema-based learning and transfer could be successfully studied within an authentic training program.

Chapter 4 presented a second experimental study that examined the effects of learner-and system-controlled timing of cueing. The main results from this study provide convincing evidence for the added value of learner control as a way to provide a more adaptive problem-based learning environment. Participants with learner-controlled cueing outperformed those with system-controlled cueing on all learning outcomes and performances on both the training task and transfer pleas. Findings support the position that just-in-time cueing on learner demand is effective for the learning and transfer of complex problem solving. Furthermore, the system-controlled cueing condition outperformed the no-cueing condition on the pleading inventory and training plea, partly replicating findings from the first experiment.

Results from a third experimental study were presented in Chapter 5. These results revealed that, next to the contribution of cueing, additional group discussions do further increase the learning outcomes on two steps of a training task for *all* participants. Individual cueing and group discussions could be fruitfully combined, with students that received ‘no cueing’ before the meeting benefiting most from additional group discussion. Analysis of the discussions and transfer pleas revealed an opposite (ceiling) effect of cueing on the level and types of cognitive activity during the group discussions; students receiving individual cueing before the meeting exhibited a lower level of cognitive activity during discussion. Transfer measures on closing pleas on a different law cases revealed the expected effect of collaboration, indicating that students help each other in mindfully abstracting and finding analogies.

Implications and guidelines

It is evident to state that all learning, especially of complex problem-solving skills, will be different and that its nature is not yet well understood in the world of design-based research. More specifically, for problem solving in various situations, it also stands to reason that one relies upon former knowledge and experiences. Instructional designers are therefore challenged to create methods, theoretical guidelines and practical implications for the design of cueing and structure for problem-solving training tasks, so that learners can be offered this necessary knowledge and experiences. This thesis has argued for and reported from research, which was carried out from the perspective of a 'whole task' approach, in which adequate process support is considered essential for training complex skills. Our research describes cueing as an adequate method to support and facilitate schema-based training to enable transfer over various problem situations. We examined process-and product-oriented cueing, system- and learner- controlled cueing, and cueing to support both individual and collaborative learning. A number of theoretical guidelines and practical implications for the design of cueing to support schema-based learning of problem- solving skills can be formulated on the basis of the research in this thesis.

Theoretical guidelines

Theoretical implications were derived from extensive literature research, and were presented in a model for schema construction and listed in guidelines for adequate cueing. This model (see Figure 2.2, on page 22) presents relationships between cueing on the one hand and schema interpretation, schema construction, and monitoring on the other hand. Eleven *theoretical guidelines* for adequate cueing state that: cueing facilitates the interpretation of available schemata in complex task performance if it (1) reflects the complexity of the task, (2) serves as an embedded support device, and (3) makes learners persevere in attaining the goal competence; cueing facilitates schema construction when it (4) reflects the relations between task characteristics, (5) saliently presents these task characteristics, (6) facilitates transfer, (7) optimizes available working memory, and (8) is presented just-in-time; and cueing facilitates monitoring when it (9) stimulates evaluative questioning during problem solving, (10) provides information about the progress, and (11) provides information about intermediate results.

Practical implications

Practical implications for the design of cueing were directly distilled from a pilot study and three experimental studies on cueing formats. The studies used the multimedia practical *Preparing a plea*, in which some of these theoretical guidelines were empirically tested and validated. A combination of an expert's worked-out solutions for steps and process worksheets in the form of driving questions for every step, as provided in *Preparing a plea*, was considered to comply with these guidelines.

The effects of either modifying or withdrawing these worked-out examples and / or process worksheets on training and transfer tasks were presented in previous chapters. Summarizing these results, we can now state six *practical implications* for the instructional design of cueing in multimedia practicals: (1) Use a combination of examples and worksheets to *motivate* students. Providing cueing by means of worked examples and process worksheets will be appreciated by students, who feel this support facilitates training and performance of complex problem-solving skills; (2) Use a *combination* of worked-out examples and process worksheets to improve training and performance on training and transfer tasks; (3) Use worked-out examples to facilitate *near transfer*, i.e. to improve performance on the training task; (4) Use process worksheets to facilitate *far transfer*, i.e. to improve performance on transfer tasks; (5) Use *learner-controlled timing* to foster more *adaptive learning* to improve personalized and more meaningful learning on training and transfer tasks; our specific study indicated that the 'teachable moment' for providing procedural information in a process worksheet can be about one quarter of the time-on-task; and (6) Use a combination of individual within-step cueing in the multimedia practical and collaborative cognitive support during *small group discussions* of these intermediate learning outcomes. Group discussion can facilitate training of complex skills and at the same time minimize necessary support to be designed and developed in multimedia practicals.

Future research

Much research on cueing remains to be done, particularly as the new instructional paradigms develop and new computer and audio-visual technologies enhance our capabilities for dynamically representing authentic problem situations and their underlying concepts in task-valid cueing formats. For instance, Atkinson, Derry, Renkl and Wortham (2002) in their review of learning from examples studies expect most important questions for future research to be: How can examples of *authentic problem solving* be designed to promote the construction of transferable structures? When and how should authentic examples be introduced into *learning communities*? What will be *effective conditions* to foster productive self-explaining of examples by learners? We end this thesis by suggesting three possible lines of future cueing research topics: adaptive cueing, authentic tasks, and generalization of findings.

Adaptive cueing

Adding more learner-control to cueing with respect to timing has clearly shown to further increase the effects of cueing on learning outcomes on both training and transfer tasks. Van Merriënboer and Sweller (in press) recently mentioned that allowing students freedom to use prompts for self-regulation (like driving questions in a worksheet) is a promising method for adaptive e-learning. When students are, in addition to the 'when' of cueing, also given control of the 'how' of instruction (e.g., by adapting the amount and complexity of instruction, and the nature of learning tasks) the positive effects on learning are expected to increase even further. Future studies could focus on the special contribution of learner control on process-oriented steps and transfer.

As an example, virtual reality (VR) offers new technological possibilities to adaptive e-learning and representing authentic learning environments, especially when learner control is required. VR adds power to scientific visualization and makes pertinent aspects and relationships within the data more salient to the viewer. A research idea could be to further *tailor* the presentation (visual cueing) to take better advantage of the human ability to recognize structures and construct schema. Different kinds of virtual reality can be distinguished (e.g., McLellan, 2003). While our studies have focused on just one type, namely "desktop VR" which provides a first-person experience 'through the window' of the computer screen, further research can be expected to expand with rapid technological growth and will be required to establish which VR environments are most effective for training complex skills, and to specify what authenticity in education really is. Authenticity, for instance, should not be mistaken by realism.

Conditions for cueing and authentic tasks

Research on task-valid cueing in *authentic learning environments* is timely and promising. Although it requires extra organizational effort and time to conduct such real world research and to face some practical concerns (Robson, 2002), the findings from this research show that instructional techniques to facilitate schema-based learning can be reliably compared in controlled experimental settings with authentic training programs of longer duration. It appears feasible to study competence-based training with relatively long, ill-structured and realistic problem-solving tasks that are directly transferable to professional practice.

However, a number *of practical concerns* have risen that need to be faced *in real world research*. Some experimental flaws and shortcomings of the research have already been mentioned. Due to ethical considerations, the experimental effects had to be reduced because participants were regular students working for credits. Even with the lack of cueing or group discussion, some support mechanisms in the program still guaranteed that participants could successfully study. Inclusion of 'very poor' or 'very good' condition would most likely have induced stronger effects of cueing and group discussion, but was not a realistic option here. Only relatively small sample sizes (about ten participants per condition) were feasible for these labor-intensive experiments, and have revealed only the strongest effects. This might explain why we only found partial support for some of our hypotheses. During experimentation, relatively little control could be exercised on participants while individually working on the program at their homes. Finally, it appeared that learning outcomes on specific tasks could only be measured reliably with instruments that were specially developed for these tasks. Using more general instruments (i.e. the plea checker) to include other tasks (i.e. transfer pleas on other law cases) appeared problematic. Future real world research is therefore challenged to find feasible ways to include larger sample size and a broader variety of tasks, while at the same time warranting independence and experimental control of the groups and reliability of measuring.

It also seems necessary to conduct more research into the *conditions for effective authentic 'whole task' training programs*, such as: the amount of practice, the importance of preparatory steps, the roles of motivation and meta cognition, the right balance between individual and group work, and the amount of structure for these tasks. The importance of high *variability of practice* was mentioned as an essential element for far transfer to occur, but the optimal amount of practice tasks is not yet known. Students working for credits are '*calculated learners*' who only want to invest time in products that are graded, and not in the preparatory, more process-oriented tasks. Training conditions should therefore be designed in such a way that these preparatory steps have to be given ample attention, since these can be expected to lead to better learning products in the long run. What exactly goes on during students' monitoring when applying cueing support needs to be further examined. A fruitful area for research would be to examine how individual *motivational factors*, learning strategies and meta cognitive activity can be improved for adaptation to a far transfer task. A further examination and determination of the optimal balance between *individual and collaborative support* in training complex problem-solving tasks is needed in order to address the 'teacher bandwith problem'. (Providing individualized learner support to increasing numbers of students is going to be problematic when teaching-capacity, needed for personalized learning experiences, remains the same or decreases.) Finally, when designing for extra collaborative support, an effective *amount of structure* in process support for such collaborative problem solving (CPS) meetings should be determined.

Generalization to other formats, domains, and media

The theoretical model and guidelines pertain to all task-valid cueing and the acquisition of all complex problem-solving skills. Practically however, the studies were limited to cueing formats within a multimedia practical in the domain of Law, and we only examined the effects of cueing on the ability to prepare a plea. Replications of our findings are required for other cueing formats, within other content domains and for other media.

Greater variance of *other task-valid cueing formats* could start by studying the effects of modeling examples and templates, the other prototypical formats in the theoretical model. Furthermore, findings need to be generalized across *other domains*, first of all those with similar ontologies (i.e. those based on heuristic rules of thumb). The instructional design of cueing to combine product-oriented worked-out examples, to support near transfer, and process-oriented process worksheets, to support far transfer, has been applied in multimedia practicals in a variety of domains. Although the learning support for particular domains may involve many different learning tools, there may be common elements (like worksheets and examples). In this respect, a promising approach could be to build *generic cueing tools* to support 'whole tasks' in various domains. Standardization should provide an important foundation for inter-operability and re-use in other domains. The development of specifications and standards for learning ontologies (e.g., IMS-LD, 2003) and for the learner model (e.g., IMS-LIP, 2003) is expected to be an interesting development here. Current educational practice in higher education shows problem-solving tasks to be supported by *other media*, like distributed learning communities and computer-supported collaborative learning (CSCL) environments. We found that a balanced combination of individual computer-based cueing and collaborative face-to-face support for complex problem solving tasks can be a feasible solution for solving the 'teacher bandwith problem'. Future research should conduct studies to compare the benefits of face-to-face collaboration (as in this study) and computer-mediated collaboration (as in most contemporary CSCL/CSCW research). We believe that the design of practice for computer-mediated collaborative settings (both synchronous and asynchronous) has much to learn from research carried out in more individual face-to-face settings. For instance, online self-organizing social systems (OSOSS) is thick with principles found in modern instructional design theories, but many unexplored areas of large-scale instructional design research on problem-based learning need pioneering. Following the findings of this research, more distributed learning environments are expected to benefit from generic cueing tools and offer future life-long learners promising, large-scale yet cost-effective, adaptive e-learning environments for the acquisition of complex skills.

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Appendices

Appendix 1. Screens of a process worksheet and worked-out example

In addition to the screendumps in previous chapters and for better readability, this appendix contains two somewhat enlarged screendumps a student might encounter when writing the pleading note (step 6) for case 'Bosmans'.

The first screen shows a part of the questions and answers (dummy text) of a process worksheet, found in the report tool on trainee's laptop in his work place (i.e. drawing up a pleading note on the left, with an a previously drawn up pleading inventory from step 3 on the right).

The second screen shows a part of a worked-out example taken from trainee's postbox in his work place (i.e. expert's answers on questions for the synopsis of step 4).


Pleit voorbereid: stagiair: zaak Bosmans; schrijven van de pleitnotitie
dossier Bosmans
pleitnotitie dossier Bosmans
pleitinventaris bij dossier Bosmans
1. inleiding (max. 10% totale tekst)
DUMMY TEXT
1a. Wordt het onderwerp van de casus genoemd én juist benoemd?
DUMMY TEXT
1b. Wordt de probleemstelling genoemd én juist geformuleerd?
DUMMY TEXT
1c. Past introductie onderwerp bij aard van pleidooi (neutraal, zakelijk of emotioneel)?
DUMMY TEXT
1d. Wordt de opbouw van het betoog en de hoofdzaken kort geschetst?
DUMMY TEXT
1e. Maakt de inleiding melding van het standpunt/de inhoudelijke conclusie?
DUMMY TEXT
2. middentekst
DUMMY TEXT
2a. Worden juridisch relevante feiten gegeven?
DUMMY TEXT
2b. Zijn juridische argumenten gegeven en zijn juiste indicatoren toegepast?
DUMMY TEXT
2c. Wordt een standpunt/conclusie met argumenten onderbouwd?
DUMMY TEXT
2d. Is de argumentatiestructuur inzichtelijk gemaakt
1a. Heeft de partij die de zaak aanhangig heeft gemaakt voor de juiste procedure gekozen en is aan alle vereisten voldaan?
DUMMY TEXT
1b. Wat wordt door partij(en) geëist/gevorderd/verzocht?
DUMMY TEXT
1c. Op welke rechtsgrond is de eis / de vordering / het verzoek gebaseerd?
DUMMY TEXT
2a. Welke feiten worden door geen der partijen betwist?
DUMMY TEXT
2b. Welke feiten worden verder nog door mijn cliënt erkend?
DUMMY TEXT
2c. Welke gegevens worden door mijn cliënt ontkent?
DUMMY TEXT
3. Wat is in deze zaak de specifieke rechtsvraag?
DUMMY TEXT
4a. Wat zijn de kernargumenten van de wederpartij?
DUMMY TEXT
4b. Wat kan ik aanvoeren tegen de kernargumenten van de wederpartij?
DUMMY TEXT
5 Welke wetsartikelen zijn hier van belang?
DUMMY TEXT
6 Aan welke criteria moet dan zijn voldaan?
vb
bewaar als tekstbestand
rapport


Pleit voorbereid: stagiair: zaak Bosmans; schrijven van de pleitnotitie
¶ synopsis bij dossier Bosmans
Beste stagiaire
Bij deze stuur ik jou mijn uitwerking van de synopsis bij het dossier Bosmans.
Je hoeft niet op alle detailvragen een antwoord te geven, maar ze kunnen wel nuttig zijn opdat je niets over het hoofd ziet.
Met vriendelijke groet, Paula van Aken.
Uitwerking `synopsis bij dossier Bosmans'
Onderstaand beantwoord ik de globale vragen. De specifieke vragen die staan in het theorieboek heb ik, voor zover dat van toepassing is, verwerkt in de beantwoording van de globale vragen.
1. Voor wie ga ik pleiten?
Van Ferdinand Don heb ik begrepen dat rechter Ernes de zaak gaat behandelen. Hij schreef dat het een vrouwelijke rechter is, hij heeft eerder al voor haar gepleit. Hij vond haar heel aardig. Zij komt erg rustig over en maakt de indruk dat zij open staat voor wat de advocaat naar voren brengt. Ferdinand Don benadrukte dat deze rechter zeer deskundig is en dat in haar vonnis altijd duidelijk blijkt dat zij alles wat tijdens het pleidooi naar voren is gebracht heeft gehoord en voor zover relevant ook laat meewegen in haar oordeel. In de zaken die Ferdinand Don voor deze rechter heeft bepleit, zijn hem zelden vragen gesteld. De advocaat krijgt van haar de ruimte om zelf op zijn eigen wijze de zaak naar voren te bengen.
2. Waar moet ik zelf op letten?
vragen
synopsis bij dossier Bosmans
DUMMY TEXT

Appendix 2. Example pleading measurement instrument

This appendix presents a translated and slightly adapted version of the original list of items which raters used to measure pleading inventory performance for the 'Bosmans' case. (The general setup for the instruments to measure pleading note and pleading performance for the 'Bosmans' case, and pleading performance for the 'Ter Zijde' case are comparable.)

A total of 90 items, subdivided over various (sub) scales are scored as either present (1) or absent (0) in the left colom. The scales pertain to either A. Content, B. Applied Law, or C. Judgement and strategy. In this ideal example all items have been scored as present, adding up to a maximum total of 108 points, or a 'G' (= good). For experimentation we used a digital version of the instrument (Excel spreadsheet) in which scores on items were automatically weighed (raters were kept unaware of item weights), and (sub) totals could be automatically summed up.

Pleading inventory 'Bosmans'

name student:……………………………………………………………

name rater: ……………………… date: ………………… ………………..

item scores		weighed scores
	Total score (qualitative)	G
90	Total score (points)	108
52	**A. Content**	61
16	*AA. Report contains reflection of juridically relevant, proven and undisputed facts*	16
1	Beunen bought motorcycle from Bosmans for 430 euro	1
1	The advertisement states that the motorcycle is fast	1
1	Both father and son Bosmans have seen the advertisement for the motorcycle	1
1	Both father and son Beunen have seen motorcycle before the purchase	1
1	Beunen has made test trial(s)	1
1	No investigation into technical state of motorcycle was instigated	1
1	Ages of opposing parties: Bosmans is 18 years of age; Beunen is 16 years of age	1
1	The motorcycle was delivered	1
1	The purchase price was paid	1
1	Motorcycle appears to be accelerated	1
1	Upon police control motorcycle appears to have frame from motorbike	1
1	Motorcycle does not comply to demands Wegenverkeersreglement (dutch traffic law)	1
1	Motorcycle is being conviscated	1
1	Motorcycle can not be technically approved	1
1	Motorcycle can no longer participate in public traffic	1
1	Beunen and Bosmans neither knew that motorcycle had frame from motorbike	1
3	*AB. Report contains the specific juridical question*	3
1	Can we speak in casu of negligence of the compliance ….	1
1	… that justifies dissolvement of the agreement …	1
1	… and gives plaintiff a right to compensation?	1
18	*AC. Facts according to prosecuting party*	26
6	**ACA. Report contains description of demands**	10
1	Dissolvement of agreement	4
1	Compensation, consisting of:	1
1	- purchase price motorcycle á 430 euro	1
1	- cancellation costs insurance á 18 euro	1
1	- costs of bailiff á 100 euro	1
1	Charging defendant for process costs	2
4	**ACB. Report contains judicial grounds of prosecuter**	4
1	Liable negligence of the compliance …	1
1	… because defendant did not deliver what was agreed upon	1
1	Beunen did not and could not have known that the motorcycle was accelerated	1
1	Beunen did not and could not have known that the motorcycle had a motorbike frame	1
8	**ACC. Report contains description of core arguments of prosecutor's demands**	12
1	Father of prosecutor explicitly asked about technical alterations, which was denied	2

1	Statement father is supported by statements son and mother	2
1	Police has determined motorcycle to be accelerated	1
1	Police has determined that the motorcycle's frame is from a motorbike	1
1	Police has determined that motorcycle can not be technically aproved	1
1	Police has determined that motorcycle can no more participate in public traffic	1
1	Prosecuting party did not know that motorcycle was accelerated	2
1	Prosecuting party did not know that motorcycle had a frame from a motorbike	2

15	*AD. Facts according to plaintiff*	16
3	**ADA. Report contains arguments for plaintiff**	3
1	Non-admissability of either claim prosecuting party …	1
1	… or dismissal of the claim	1
1	Charging prosecutor for process costs	1
2	**ADB. Report contains judicial grounds for plaintiff**	3
1	What was agreed upon has been delivered …	2
1	… so there is no neglicence in compliance	1
10	**ADC. Report contains core arguments and opposing arguments for plaintiff**	10
1	Both parties could not know about the acceleration from the advertisement	1
1	Prosecuting party could know about acceleration from test trial experience	1
1	Statement P.Pietersen confirms Bosmans notifying Beunen that motorcycle was accelerated	1
1	Father Beunen was never informed that nothing was technically altered; in fact some text of the advertisement has been explained to him	1
1	Mother Beunen was only available for a minute during conversation, so her statement is not valid (no observation of her own)	1
1	Beunen took the risk that motorcycle would not be allowed in public traffic, because he knew about legal demands	1
1	With analogy to the High Court session of 15 november 1985, RvdW 1985, 210 the purchasing party must investigate the technical state of a second-hand motorcycle; this is certainly the case when test trials have already revealed that the motorcycle does not fit legal demands	1
1	Beunen was well aware that he bought an accelerated motorcycle	1
1	Bosmans did not know about the frame (because he was able to insure the motorcycle), and that's one more reason why the motorcycle was denied access to public traffic	1
1	Both dissolving the agreement and compensating by restituting the purchasing price is not possible	1

33	**B. Applied law**	41

27	*BA. Legally*	34
6	**BAA. Report contains all (possible) applied law articles**	9
1	Art. 6:265 BW onwards relating the dissolvement of agreements	2
1	Art. 6:271 BW relating to obligations when dissolving	1
1	Art. 6:74 BW relating to compensation	2
1	Art. 6:277 BW relating to compensation	1
1	Art. 6:75 en 6:78 BW relating to circumstances and accountability	2
1	Art. 6:95 BW onwards relating to the amount of the compensation	1
15	**BAB. Report contains criteria for allowing the applied law articles**	15
1	(relating to dissolvement) there should be a mutual agreement	1
1	(idem) there should be negligence in the conformance	1
1	(idem) the negligence should justify the dissolvement	1

1	(idem) no extra claims when negligence is permanently or temporarily impossible	1
1	(idem) when conformance is still possible, the right to dissolve only occurs when the debtor is negligent	1
1	(relating to compensation) there must be some kind of negligence in the conformance	1
1	(idem) negligance should be attributable to the debtor	1
1	(idem) there must be damage	1
1	(idem) there must be a causal relation between negligence and damage	1
1	(idem) as far as conformance is permanently impossible, no other claims are made	1
1	(idem) as far as conformance is not permanently impossible, the debtor must be negligent	1
1	(relating to the type of compensation) additional compensation for creditor, besides conformance, alternative conformance or dissolvement	1
1	- (idem) compensation for damage due to delay	1
1	- (idem) compensation due to bad performance	1
1	(idem) demand for causality art. 6:98 BW	1
6	**BAC. Report contains judicial consequences of applied law articles**	10
1	(relating to negligence in the conformance) dissolving agreement	2
1	(idem) demand for over-ruling based on art. 6:271 BW (Bosmans must repay purchase price and Beunen must return motorcycle	2
1	(idem) when negligence is accountable: additional compensation	2
1	(idem) when negligence is not accountable: no additional compensation	2
1	(relating to no negligence in the conformance) no dissolvement of the agreement	1
1	(idem) no compensation	1
6	*BB. Jurisprudence (only if applicable)*	7
2	**BBA. Report contains (possible) applied jurisprudence**	3
1	Jurisprudence is stated, but not the right one	1
1	Relevant jurisprudence High Court 15 november 1985, RvdW 1985, 210 is stated	2
4	**BBB. Report contains consequences attached to applied jurisprudence**	4
1	(in principle) the buyer should investigate the motorcycle to make sure what is the (technical) state of the object he buys	1
1	When buyer is negligent in his duty to investigate, (in principle) the consequences of technical alterations are at his own expenses	1
1	Only the (professional) salesperson has a duty to inform about the obligations for investigation and / or information	1
1	When a (professional) salesperson neglects these obligations, the duty to investigate for the buyer is no longer valid	1
5	**C. Judgement and strategy**	6
3	*CA. Choice of a good strategy*	3
1	Convince judge that Beunen knew he had bought an accelerated motorcycle	1
1	… and because motorcycle was accelerated, it did not comply to legal demands: Beunen therefore took the risk that other parts (among which the frame) would not be in order also	1
1	Convince judge that Bosmans did not know that the motorcycle had a frame from a motorbike, since he was able to insure the motorcycle	1
2	*CB. (Reasonable) estimation of chances client*	3
1	Report does contain an estimation of chances for client, but this is not realistic (e.g., does include chances of success by a 'clear sweap')	1
1	Report contains an estimation of the chances for client, stating that client has a reasonable chance for success	2

Summary

The central question of this thesis is: *How should support for the acquisition of problem-solving skills in competence-based multimedia practicals be designed?* Computer programs that contain various information modes (multimedia), and are aimed at the acquisition and application of problem-solving skills (competences), are referred to as competence-based *multimedia practicals*. A competence in a professional situation could be dealing with modeling stress-factors that cause mental overload among bus drivers (domain: labor psychology), identifying environmentally protected areas (domain: soil science), marketing a chain of recreation parks (domain: business administration), and other competences. The importance of competences is increasing because companies no longer settle for graduates that just know and do a lot in general; they are also supposed to be able to actually apply this general knowledge and skills in specific professional situations. The sustainability of knowledge is decreasing rapidly in today's information society. In our professional lives we can no longer depend on routines, but have to rely on our flexible problem-solving behavior. The current education is staying behind this societal trend and still places the learning of isolated facts and skills in the central position. Because education is scaled-up and because of the needs for distance education and life long learning, less time remains for teacher-intensive training that is required to train competences. Multimedial practicals can be individually studied and may offer a feasible solution to this problem, but have not yet been extensively researched. We can not take for granted that such programs will be effective; we have to consider ways of support for learners that acquire competences.

An important and promising way to offer support is by offering task-valid cognitive feedback or *cueing*. We do not yet know how and when to provide cueing in multimedia practicals in a way that allows competences not just to be trained but also to be applied in other situations. The ability to apply what is learned in other situations is called *transfer*. So far, a lot of feedback research has been carried out, but this mainly dealt with small, knowledge-aimed, procedural tasks in controlled (laboratory-like) experimental settings. Besides this, the possibilities of transfer to authentic environments have hardly been studied and feedback was restricted to learning *products*, e.g. feedback on giving the right answer. The challenge for educational designers is now to embed cueing in such a way that the learning *process* can be supported as well. Learners must be supported to acquire competences that are relevant for their domain in such a way that they can be applied outside the computer program later. In order to achieve this we must first of all decide on authentic tasks and realistic environments. Such tasks are characterized by a

substantial study load of minimally 10 hours, and are therefore divided in several steps to acquire the competence. For each step cueing has to be provided. This thesis argues how and when this cueing should be provided from a theoretical framework with guidelines, and describes three experiments that examined the actual use of cueing within authentic educational settings.

This research takes *schema theory* as its starting point. A schema is a cognitive structure that enables people to recognize objects and to classify them as a certain type. A child's preliminary schema for 'animal' for instance can be 'walks on four legs, has hair everywhere and a tail', which automatically classifies most dogs and cats. This schema needs further elaboration (construction) when the child starts recognizing birds, fish, insects or other phenomena as animals. Problem schemata offer analogies for problems. Problem schemata also have to be automated first to be applied in similar situations (we call this 'near transfer'), and have to be constructed further to be applied to other situations (we call this 'far transfer'). An advanced student can abstract from known training situations and apply what was learned on unknown situations. Noticing analogies is a prerequisite for successful transfer to unknown problem situations in professional practice. As long as students do not notice analogies spontaneously, cueing should explicitly state them.

This research used adapted versions of the multimedia practical *Preparing a plea* that trains law students to prepare a plea in a systematic way. We experimented with two formats of task-valid cueing. The first format are *worked-out examples* that offer specific, product-oriented information about possible outcomes of the various steps, for instance when a pleading note has to be written for a certain law case; these examples are expected to best support 'near transfer'. The second format are *process worksheets* that contain general, process-oriented questions that need to be answered for each law case, for instance when drawing up a pleading inventory; these worksheets are expected to best support 'far transfer'. As a result of the research, this thesis presents a theoretical model, theoretical guidelines and practical implications for the use of cueing in multimedia practicals. The *model for schema construction* describes the relations between cueing, problem schemata and learning outcomes. Resulting from a literature study, *theoretical guidelines for cueing* are derived and described. Cueing should: (1) reflect the complexity of the task; (2) serve as an embedded support device; (3) make learners persevere in attaining the goal competence; (4) reflect the relations between task characteristics; (5) saliently present task characteristics; (6) facilitate transfer; (7) optimize available working memory; (8) be presented just-in-time; (9) stimulate evaluative questioning during problem-solving; (10) provide information about the progress; and (11) provide information about intermediate results.

The model and guidelines were used to argue why a combination of examples and worksheets is expected to best support the acquisition of competences. Students participating in a pilot study report appreciation for these formats of cueing. They feel that cueing leads to improved pleas and more efficient searching behavior. When the pilot study revealed that the presence of worked-out examples and process worksheets was both appreciated and motivating for students, the effects of cueing were further studied in three experiments. The guidelines have been examined with adapted versions of the program that vary the formats and timing of cueing. The effects of these experimental variations on the learning outcomes of the training task (pleading inventory, pleading note and plea) and transfer tasks (pleas on other cases) were measured and compared.

The results of a first experiment, varying the orientation of cueing, indicate that worked-out examples indeed contribute to improved learning outcomes on the training task and ‘near transfer’, and that process worksheets contribute to the quality of a delayed plea and ‘far transfer’. This transfer effect could however not be found for a transfer plea that was held shortly after training. A second experiment, varying the timing of cueing, revealed that cueing contributes most to improved learning outcomes of both the training and transfer task when learners can control when to use it. The teachable moment for a process worksheet is hard to determine in advance. When learners are in control over this moment during task execution, individual differences between students become apparent. A third experiment, varying both cueing and collaboration, shows that additional small group discussions combined with cueing further improve the learning outcomes on the training and transfer task. The effect of group discussions on the transfer task was however only found with students receiving no cueing with the program. To fully design cueing in advance is often difficult and costly, and this last result indicates that it would be worthwile to further explore peer-supported cueing (partially and combined with programmed cueing) during runtime of courses.

Based on the pilot study and three experiments, following *practical implications* for designing cueing in comptence-based multimedia practical are presented: (1) use a combination of examples and worksheets to motivate students; (2) use a combination of worked-out examples and process worksheets to improve training and performance on both training and transfer tasks; (3) use worked-out examples to facilitate near transfer, i.e. to improve performance on the training task; (4) use process worksheets to facilitate far transfer, i.e. to improve performance on transfer tasks; (5) use learner-controlled timing to foster more adaptive learning to improve personalized and more meaningful learning on both training and transfer tasks; and (6) use a combination of individual within-step cueing in the multimedia practical and collaborative cognitive support during small group discussion*s* of these intermediate learning outcomes.

These theoretical guidelines and practical implications need to be further examined and validated for other formats of cueing, in other situations and media, and for other domains than Law. The general discussion contains some suggestions for future research. This thesis offers sufficient proof to conclude that research into cueing for competence-based learning environments is needed, timely and hopeful. It appears feasible to conduct experimentally controlled studies within authentic learning situations. Although extra time and energy are related to this research and only small groups of participants can be followed during training programs of longer duration, societal trends and the need for flexible problem-solvers do justify an increase in this type of real world research.

Samenvatting

In dit proefschrift staat de volgende vraag centraal: *Hoe kunnen we aanwijzingen voor competentiegerichte computerprogramma's ontwerpen waarmee de verwerving van complexe vaardigheden kan worden ondersteund?* Computerprogramma's die gebruik maken van verschillende modaliteiten om informatie aan te bieden (multimedia), en zijn gericht op het aanleren en toepassen van probleemoplossende vaardigheden (competenties), worden hier aangeduid met competentiegerichte *multimediale practica*. Bij een competentie in een authentieke beroepspraktijk kunt u bijvoorbeeld denken aan het kunnen bepalen van factoren die stress veroorzaken onder buschauffeurs bij een bepaalde onderneming (domein: arbeidspsychologie), het kunnen aanwijzen van milieubeschermingsgebieden (domein: bodemwetenschappen), de marketing van een keten van recreatieparken (domein: bedrijfskunde), en vele andere competenties. Het belang van dergelijke competenties neemt toe omdat bedrijven niet langer afgestudeerden willen die alleen maar veel weten en kunnen; ze moeten deze algemene kennis en vaardigheden ook daadwerkelijk in een specifieke beroepspraktijk kunnen toepassen. In de huidige informatiemaatschappij wordt de houdbaarheid van kennis steeds korter. We moeten ons, in plaats van op routinematig handelen, steeds vaker verlaten op flexibel probleemoplossend handelen. Het huidige onderwijs blijft achter bij deze maatschappelijke ontwikkeling en stelt het aanleren van geïsoleerde kennis en vaardigheden nog steeds centraal. Door de schaalvergroting van het reguliere onderwijs en de behoefte aan afstandsonderwijs en levenslang leren is er bovendien minder tijd voor docentintensieve taken die voor het aanleren van competenties nodig zijn. Multimediale practica kunnen individueel worden doorlopen en bieden mogelijk een haalbare oplossing, maar er is nog niet veel onderzoek naar gedaan. We kunnen er niet zonder meer vanuit gaan dat dergelijke programma's effectief zijn; ook binnen deze programma's zal moeten worden nagedacht over de manier waarop de lerenden zullen moeten worden ondersteund bij het aanleren van de gewenste competenties.

Een belangrijke en veelbelovende vorm van ondersteuning zijn *taakgerichte aanwijzingen*. We weten echter nog niet echt goed hoe en wanneer in multimediale practica aanwijzingen gegeven moeten worden, zodat competenties niet alleen worden aangeleerd maar ook in andere situaties toegepast kunnen worden. Het vermogen het geleerde ook in andere situaties te kunnen gebruiken wordt *overdracht* (Engels: transfer) genoemd. Er is wel veel onderzoek naar aanwijzingen gedaan, maar meestal met behulp van korte, kennisgerichte of procedurele taken in gecontroleerde (laboratoriumachtige) experimentele omgevingen. Daarbij zijn de mogelijkheden van overdracht naar authentieke omgevingen niet onderzocht. Bovendien bleven deze aanwijzingen vaak beperkt tot de leerproducten, bijvoorbeeld door het geven van het goede antwoord. De uitdaging voor onderwijsontwerpers bestaat er nu in aanwijzingen in programma's op zo'n manier te verwerken dat ook het leer*proces* kan worden ondersteund. Lerenden moeten de voor hun domein relevante competenties zodanig kunnen verwerven dat ze deze later ook buiten het programma kunnen gebruiken. Daarvoor moeten we allereerst authentieke taken en levensechte omgevingen bedenken. Dergelijke taken worden gekenmerkt door een substantiële studielast van minimaal tien uur en zijn daarom opgedeeld in stappen die gezet moeten worden om de competentie aan te leren. Bij elke stap moeten aanwijzingen worden gegeven. Hoe en wanneer deze aanwijzingen gegeven moeten worden wordt in dit proefschrift in een theoretisch model met richtlijnen omschreven en in een drietal experimentele studies binnen authentieke omgevingen in de onderwijspraktijk onderzocht.

Dit onderzoek gaat uit van zogenaamde *schematheorie*. Een schema is een cognitieve structuur die mensen in staat stelt objecten te herkennen en te classificeren als van een bepaald type. Voor een kind kan een voorlopige schema voor 'dier' bijvoorbeeld zijn 'loopt op vier poten, heeft overal haar en een staart', waarmee de meeste katten en honden automatisch kunnen worden geclassificeerd. Dit schema zal echter nog verder moeten worden geconstrueerd wanneer het kind ook vogels, vissen, insecten of andere verschijnselen als dieren gaat herkennen. Probleemschema's zijn analogieën voor problemen. Ook voor probleemschema's geldt dat ze eerst moeten worden geautomatiseerd om in soortgelijke probleemsituaties te kunnen worden toegepast (we noemen dit 'nabije overdracht'), en eerst moeten worden geconstrueerd om op onbekende problemen te kunnen worden toegepast (we noemen dit 'verre overdracht'). Een gevorderde student kan abstraheren van trainingsituaties en het geleerde toepassen op onbekende situaties. Het opmerken van analogieën is dus een voorwaarde voor het optreden van succesvolle overdracht naar probleemsituaties in de beroepspraktijk. Zolang dat bij studenten nog niet spontaan gebeurt, dragen aanwijzingen deze analogieën expliciet voor hen aan.

Er is in dit onderzoek gebruik gemaakt van aangepaste versies van het multimediale practicum *Pleit voorbereid* dat rechtenstudenten op systematische wijze leert een pleidooi voor te bereiden. We hebben geëxperimenteerd met twee soorten op de uitvoering van deze taak gerichte aanwijzingen. Ten eerste *uitgewerkte voorbeelden* die specifieke, productgerichte informatie bieden over mogelijke uitkomsten van de verschillende stappen, bijvoorbeeld als een pleitnotitie voor een bepaalde rechtszaak moet worden geschreven; van deze voorbeelden wordt verwacht dat ze vooral 'nabije overdracht' ondersteunen. Ten tweede *proceswerkbladen* die algemene, procesgerichte vragen bevatten die per stap voor elke rechtszaak moeten worden beantwoord, bijvoorbeeld als een pleitinventaris moet worden samengesteld; van deze werkbladen wordt verwacht dat ze vooral 'verre overdracht' ondersteunen.

Dit onderzoek heeft een theoretisch model, theoretische richtlijnen en praktische aanbevelingen voor gebruik van aanwijzingen in multimediale practica opgeleverd. Het proefschrift beschrijft een *model voor schemaconstructie* waarin de relatie tussen taakgerichte aanwijzingen, probleemschema's en leeruitkomsten wordt weergegeven. Vanuit een literatuurstudie worden *theoretische richtlijnen* afgeleid waaraan taakgerichte aanwijzingen moeten voldoen. Taakgerichte aanwijzingen moeten: (1) de complexiteit van de taak weergeven; (2) functioneren als ingebouwde ondersteuning in het programma; (3) lerenden stimuleren vol te houden de competentie te verwerven; (4) de relaties tussen de taakkenmerken weergeven; (5) de taakkenmerken expliciet weergeven; (6) overdracht ondersteunen; (7) optimaal gebruikmaken van het beschikbare werkgeheugen; (8) tijdig gepresenteerd worden; (9) monitoring mogelijk maken door evaluatieve vragen; (10) informatie over de voortgang verstrekken; en (11) informatie over tussentijdse resultaten verstrekken.

Met dit model en deze richtlijnen is beargumenteerd waarom een combinatie van voorbeelden en werkbladen de verwerving van competenties ondersteunt. Deelnemende studenten aan een verkennende studie geven aan deze aanwijzingen te waarderen. Ze denken dat de aanwijzingen tot betere pleidooien en efficiënter opzoekgedrag leiden. Nadat uit deze verkennende studie was gebleken dat studenten de aanwezigheid van uitgewerkte voorbeelden en proceswerkbladen waarderen en motiverend vinden, zijn de effecten van deze aanwijzingen op leeruitkomsten verder bestudeerd in een drietal experimenten. Deze richtlijnen zijn onderzocht met verschillende versies van het programma waarmee aanwijzingen in verschillende soorten en op verschillende momenten worden aangeboden. De effecten van deze variaties op de leeruitkomsten van een trainingtaak (pleitinventaris, pleitnotitie en pleidooi) en overdrachttaken (pleidooien over andere zaken) zijn gemeten en vergeleken.

De resultaten van een eerste experiment, waarin met de verschillende soorten aanwijzingen is gevarieerd, laten zien dat uitgewerkte voorbeelden inderdaad bijdragen aan betere leeruitkomsten op dezelfde trainingtaak en 'nabije overdracht', en proceswerkbladen bijdragen aan de kwaliteit van een uitgesteld pleidooi en 'verre overdracht'. Dit laatste effect kon echter niet worden vastgesteld bij een overdrachtpleidooi dat kort na de training werd gehouden. Uit het tweede experiment, waarin met de aanbiedingswijze van de aanwijzingen is gevarieerd, bleek dat aanwijzingen sterker bijdragen aan betere leeruitkomsten van de trainingtaak én het overdrachtpleidooi wanneer studenten zelf kunnen bepalen wanneer ze er gebruik van maken. Het blijkt lastig te zijn het juiste moment van aanbieding van een proceswerkblad vooraf te bepalen. Wanneer studenten tijdens het uitvoeren van de taak controle hebben over het moment van aanbieding, dan blijken er verschillen tussen studenten te bestaan. Het derde experiment, waarin zowel werd gevarieerd met het aanbieden van aanwijzingen als extra groepsdiscussies, toont aan dat een aanvullende groepsdiscussie in combinatie met aanwijzingen de leeruitkomsten op de trainingtaak en op het overdrachtpleidooi verder verbetert. Dit effect van de groepsdiscussie op de overdrachtpleidooien werd echter alleen gevonden voor studenten die geen aanwijzingen in het programma kregen aangeboden. Studenten die zowel aanwijzingen als groepsdiscussie kregen aangeboden hebben de hoogste leeruitkomsten op de training- en overdrachttaak. Maar de groei in leeruitkomsten en de kwaliteit van de groepsdiscussie is het hoogst voor studenten die eerder geen aanwijzingen in het programma kregen. Omdat het vooraf ontwerpen van aanwijzingen moeilijk en kostbaar is, geeft dit laatste resultaat uit het derde experiment aan dat aanwijzingen (gedeeltelijk en in combinatie met aanwijzingen in het programma) ook tijdens het volgen van onderwijs door medestudenten gegeven kunnen worden.

Op basis van de verkennende studie en drie experimenten zijn voor het ontwerpen van competentiegerichte multimediale practica de volgende *praktische aanbevelingen* te geven: (1) gebruik een combinatie van voorbeelden en werkbladen om studenten te motiveren; (2) gebruik een combinatie van voorbeelden en werkbladen om de leeruitkomsten op zowel training als overdracht taken te ondersteunen; (3) gebruik voorbeelden om leeruitkomsten op de training taak (nabije overdracht) te ondersteunen; (4) gebruik werkbladen om leeruitkomsten op overdracht taken (verre overdracht) te ondersteunen; (5) gebruik controle door lerende over aanwijzingen om beter, persoonlijker en betekenisvoller leren op zowel training als overdracht taken mogelijk te maken; en (6) gebruik een optimale combinatie van individuele aanwijzingen in het programma met aanwijzingen van medestudenten gedurende kleine groepsdiscussies over leeruitkomsten.

Bovengenoemde theoretische richtlijnen en praktische aanbevelingen zullen uiteraard verder moeten worden onderzocht en gevalideerd voor andere typen aanwijzingen, in andere situaties en media en voor andere domeinen dan Rechten. De afsluitende discussie bevat daartoe enkele suggesties. Dit proefschrift biedt voldoende aanknopingspunen om te kunnen concluderen dat onderzoek naar nieuwe vormen van aanwijzingen binnen competentiegerichte leeromgevingen gewenst, uiterst actueel en hoopgevend is. Het blijkt mogelijk experimenteel gecontroleerde studies binnen authentieke leersituaties uit te voeren. Hoewel extra tijd en energie verbonden zijn aan soortgelijk onderzoek, en slechts relatief kleine groepen participanten kunnen worden gevolgd gedurende langere trainingsprogramma's, rechtvaardigen maatschappelijke ontwikkelingen en de toenemende behoefte aan flexibele probleemoplossers op de arbeidsmarkt een toename van dit soort authentiek onderzoek in de toekomst.

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Curriculum Vitae

Hans Hummel was born on April 2, 1960 in Ridderkerk, in the Netherlands. He attended secondary school (Atheneum β) at the Wolffert van Borselen College in Rotterdam from 1972 to 1978.

After secondary school, Hans started his study at the University of Leiden. He holds masters degrees in Pedagogy (1985) and Educational Psychology (1985), with minors in Informatics and Orthodidactics. His master's thesis reports a study into problem-solving approaches taken by children with learning deficits.

From 1983 to 1987, Hummel coordinated innovative projects applying ICT in primary and vocational education. That time he worked as computer programmer for the Pedological Institute and assistant-director for LICOR (Leiden Interdisciplinary Centre for Educational Research) in Leiden, and as educational advisor for IVIO (educational publisher) in Lelystad.

In 1987 Hans moved to Limburg to join the Open University of the Netherlands (OUNL) as an educational technologist. He has (co-) developed dozens of distance courses in multi-disciplinary teams, and has lead the development of interactive computer programs in a variety of domains. During later years he was OUNL-spokesman for corporate communication related to innovation, educational (e-learning) consultant to various external parties (commercial and not-for-profit), and has been involved in the design, development and further dissemination of innovative learning technology (mainly the IMS-Learning Design specification). Recently he is researching critical facilities for life-long learning networks.

From 1997 onwards, Hummel with others developed a new educational method for use in both vocational education and professional training programs (published by Wolters-Noordhoff); a series of books and interactive programs has since reached tens of thousands to learn various general skills (like setting up research, reporting and presentation skills, and projectmanagement). His main research interest is the instructional design and realization of competence-based courses, especially by means of electronic environments.